[illegible]inary at Princeton N.J. by
the Rev. Samuel Miller D.[illegible]

A BRIEF RETROSPECT OF THE EIGHTEENTH CENTURY.

PART FIRST;

IN TWO VOLUMES:

CONTAINING

A SKETCH OF THE REVOLUTIONS AND IMPROVEMENTS IN SCIENCE, ARTS, AND LITERATURE, DURING THAT PERIOD.

BY SAMUEL MILLER, A. M.

ONE OF THE MINISTERS OF THE UNITED PRESBYTERIAN CHURCHES IN THE CITY OF NEW-YORK, MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY, AND CORRESPONDING MEMBER OF THE HISTORICAL SOCIETY OF MASSACHUSETTS.

VOL. I.

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TO

JOHN DICKINSON, ESQ. LL. D.

LATE PRESIDENT OF THE STATE OF DELAWARE,

AND

PRESIDENT OF THE SUPREME EXECUTIVE COUNCIL OF THE COMMONWEALTH OF PENNSYLVANIA.

DEAR SIR,

IN finding your Name prefixed to the following pages, without permission, I trust you will feel no emotion more unfavourable than that of surprize. I know not, indeed, to whom I could dedicate such a work as this with more propriety than to an elegant Scholar, a comprehensive Observer of a large portion of the century attempted to be reviewed, a Master of so many of its literary and scientific improvements, a conspicuous Actor in some of its most memorable and important transactions, an able and eloquent Defender of his country's rights, a munificent Patron of American literature, and (if personal or local feelings may be allowed to intrude) a uniform and affectionate Friend of my honoured Parents, and one of the most illustrious of those who owe their birth to my native State.

Among the numerous opinions expressed in these volumes, you will, no doubt, find some which totally differ from your own; and others which more attentive and enlarged views would have taught me considerably to modify or amend. Of the former you will not consider this public address as implying or soliciting your approbation. Of the latter I am confident you will be disposed to form a candid and even an indulgent estimate.

But with respect to some of the leading opinions delivered in the following sheets, I am happy in the assurance that you perfectly coincide with me. To all that is said of the perfect harmony between the RELIGION OF CHRIST and genuine Philosophy, and of the illustration and support which the former has received at every successive step of the latter in the last age; to every unfavourable judgment pronounced on those theories, falsely called philosophy, which pervert reason, contradict Revelation, and blaspheme its divine AUTHOR; and to every expression of satisfaction at the progress of elegant letters and substantial science, as tending to promote the dignity and happiness of man—to opinions and sentiments like these, I know too much of your character to doubt of receiving your sanction.

Those who, like yourself, contemplate every department of human affairs through the medium of Christian principles, while they see much to deplore, see also much to approve and

admire in the history of science for the last age. What effect the knowledge bequeathed by that age may have on the harmony, virtue and happiness of mankind in the one on which we have entered, is known only to infinite Wisdom. Let us, however, indulge in favourable anticipations as long as we can. In all events we are assured, that this, as well as all the other fruits of human genius and activity, will be made conducive to the welfare of the good, in a more enlightened and a more happy world.

I am, dear Sir,
With much respect,
Your obliged and obedient servant,

SAMUEL MILLER.

New-York, Nov. 25, 1803.

PREFACE.

A SIMPLE history of this publication will best unfold its design, and will form the best apology for its numerous imperfections. On the first day of January, in the year 1801, the author being called, in the course of his pastoral duty, to deliver a sermon, instead of choosing the topics of address most usual at the commencement of a *new year*, it occurred to him as more proper, in entering on a *new Century*, to attempt a review of the preceding age, and to deduce from the prominent features of that period such moral and religious reflections as might be suited to the occasion. A discourse, formed on this plan, was accordingly delivered. Some who heard it were pleased to express a wish that it might be published. After determining to comply with this wish, it was at first intended to publish the original discourse, with some amplification; to add a large body of notes for the illustration of its several parts; and to comprise the whole in a single volume. Proposals were issued for the publication in this form, and a number of subscribers gave their names for its encouragement.

Little progress had been made in preparing the work, on this plan, for the press, before the objections to such a mode of arranging the materials appeared so many and cogent, that it was at length thought best to lay aside the form of a sermon, and to adopt a plan that would admit of

more minuteness of detail, and of greater freedom in the choice and exhibition of facts. This alteration in the structure of the work led to an extension of its limits; materials insensibly accumulated; and that portion which was originally intended to be comprised in a third or fourth part of a single volume gradually swelled into two volumes.

It is probable that one of the first reflections made by most readers of the following pages, will be, that the plan is too extensive to be well executed by *any* individual; and that it was peculiarly presumptuous in one of comparatively small reading, and who could not obtain access to ample libraries, to undertake such a work. The author feels the justness and weight of this reflection; and is sensible that to present a full and satisfactory view of any one of the departments embraced by this Retrospect, would be a task beyond his powers; would afford abundant employment, for many years, to a mind much more mature, active, and enlightened than his. Why then, it will be asked, did he adventure in so arduous an enterprize? In answer to this question, he must ingenuously confess, that he engaged without due consideration, and did not begin suitably to estimate the extent and difficulty of the task till he had proceeded too far to retract. He is also bound in candour to declare, that his own instruction and improvement were among his principal motives in undertaking and prosecuting this work. Being persuaded that writing on a subject is one of the best means of methodizing and correcting one's own views of it; and hoping that, while he informed himself, he might amuse, if not instruct others, he submitted to the toil of collecting and arranging the materials which are here presented. If

none of his readers should be able to derive either entertainment or information from the following sheets, he has the satisfaction of reflecting, that he himself derived both from the labour of preparing them for the press.

Though the greater part of this work consists of compilation; yet the writer claims to be something more than a mere compiler. He has offered, where he thought proper, opinions, reflections, and reasonings of his own; and though many of these are adopted, perhaps too hastily, from others, there are some of which all the praise and all the blame belong to himself. He is not, however, solicitous to discriminate, even if it were possible, between these several parts of the work. If the exhibition of facts and opinions, so far as it goes, be tolerably just, the question whence they originated is of little consequence to the reader.

With respect to the division and arrangement of the subjects, it was judged advisable to adopt rather a *popular* than a *scientific* plan. This plan is, no doubt, liable to some objections; but it appeared better suited to the purpose in view than any other that presented. The reader will observe that the sciences of *Theology*, *Morals*, and *Politics* are not noticed in this first Part. The reason of the omission is, that it appeared most proper to leave what may be said concerning the revolutions and improvements in these three interesting departments of science, respectively, to stand as preliminaries to the three remaining divisions of the work, in which some account will be attempted of the great events in the Christian Church, in the Moral World, and in Political Principles and Establishments, during the last century. It was supposed that in this connection the rise, progress, and in-

fluence of new systems, and modes of thinking, might be exhibited with greater advantage, and perused with more satisfaction.

As the author aimed at nothing more than a *brief retrospect* of the period to which this work is devoted, it was impossible for him to do more, consistently with his plan, than to mention the *principal* discoveries, inventions, improvements and writers, under each head; and even these could only be noticed with great brevity, and in very general terms. To have attempted minute details, and particular explanations, would have extended the work to many volumes. With respect to the choice which has been made of facts and names, the degree of importance ascribed to them, and the proportion of room and attention allotted to each, different readers will, no doubt, entertain different opinions. Every one will be apt to suppose that the particular names and studies to which he is most attached, are not noticed with sufficient respect, or dwelt upon at sufficient length. The author can only say, that, in general, he indulged in more or less prolixity, according to his ideas of the importance of the several subjects, the extent of his acquaintance with them, or the degree in which they interested his own mind. That from such a multiplicity of objects, he often selected injudiciously, and made an erroneous estimate of their comparative value, is altogether probable.

Although the very nature of the work required that all the subjects brought into view should be treated superficially, and that nothing more than rapid outlines should be attempted; yet the intelligent reader will, doubtless, discern, that the mode of treating some of the subjects manifests a very small and partial acquaintance with them. For the

want of more just and enlarged views, the author fears he has often written in a crude and unsatisfactory manner on topics which, in the same compass, might have been better discussed. In some instances, however, he has failed of giving a more satisfactory account of the additions made to science, by distinguished individuals, from another cause: Where it would have been impossible to state the precise limits of what each has done to advance our knowledge of a particular subject, without going into a discussion of many pages, little more is frequently attempted than to give a list of the names of those individuals, on the presumption that the inquisitive reader will seek for a more full account of their respective claims elsewhere.

It will not be supposed that the author has attentively read all the works concerning which he delivers opinions. Some of them he never saw, and has ventured to give their character entirely on the authority of those whom he considers better judges than himself. Many he has seen and consulted, with more or less attention, as his avocations allowed. It is only a small part which he can claim the honour of having read and studied with care. It is probable, however, that he might have spared himself the trouble of making this confession; symptoms of superficial reading, or of striking unacquaintance with many works of which he speaks, will, no doubt, be often discovered.

In enumerating the principal writers on the various subjects reviewed, it will be observed that those who have written in the English language engage the largest share of the author's attention. The reason of this is obvious; he is best acquainted with such writers; and from his ig-

norance of most of the languages of the continent of Europe, he has probably failed of mentioning many works quite as worthy of respectful notice as others on which he has bestowed high praise. Perhaps a still more formal apology will be deemed necessary for the disposition to introduce American writers and publications, even of moderate character, which he has so frequently discovered. But besides indulging a natural partiality for his own country, which is at least pardonable, he was desirous of collecting and exhibiting as much information on the subject of American literature as the nature of his undertaking admitted. And as no attempt to give a general historical view of this subject has ever been before made; as a considerable portion even of the humble and meagre records from which he has drawn his materials, are daily perishing; and as peculiar circumstances sometimes give to literary characters and events a relative importance, beyond their absolute value, he thought it advisable to take notice of more obscure names, and of smaller publications, than could with propriety have been mentioned in countries of a more mature literary character. Perhaps, however, in his zeal to collect every thing he could find on this subject, he has sometimes descended too low.

Should any reader be offended by the language of panegyric which is frequently bestowed on the intellectual and scientific endowments of some distinguished abettors of heresy or of infidelity, he is entreated to remember that justice is due to all men. A man who is a bad Christian may be a very excellent mathematician, astronomer, or chemist; and one who denies and blasphemes the Saviour may write profoundly and instructively on some branches of science highly interesting to

mankind. It is proper to commiserate the mistakes of such persons, to abhor their blasphemy, and to warn men against their fatal delusions; but it is surely difficult to see either the justice or utility of withholding from them that praise of genius or of learning to which they are fairly entitled.

It will probably be remarked, by the intelligent reader, that a due *proportion* between the parts of this work, according to the relative importance and extent of each subject, is not always preserved. Had the manuscript been completed before any part of it was sent to the press, faults of this kind would, no doubt, have been, in some degree, avoided; but the truth is, that the first pages of the manuscript were put into the hands of the printer before a single chapter of the work had been fully written; and each successive sheet was prepared, from the materials previously collected, at the call of the printer, and amidst the hurry of incessant professional labours. It is scarcely necessary to add, that this race with the press frequently rendered impossible that laborious investigation, and that careful correction which were highly desirable: nor could the author excuse himself for conduct so manifestly indiscreet, had he duly considered beforehand the nature and magnitude of the engagement. But it must be acknowledged, that as he entered on the work without duly appreciating the arduousness of his undertaking, so every step in the pursuit convinced him more and more of its extent and difficulty; that in the prosecution of his task he wished an hundred times he had never undertaken it; and that now it is brought to a close, few readers can be more sensible than he is himself of its numerous and great defects.

It will be observed, that *three* parts of the original plan yet remain to be executed. Whether the execution of the whole will be attempted depends, in some measure, on the reception which shall be given to this *First Part.* The author is particularly desirous of completing the fourth and last division; viz. that which relates to the Literature, Science, Revolutions, and principal Events of the Christian Church during the last age; and even if he should be compelled to abandon the two intermediate divisions, he cherishes the hope of being able, if his life should be spared, to lay something before the public on this favourite subject.

The reader is particularly requested not to overlook the *Additional Notes.* They will be found to supply some of the deficiencies, and to correct some of the errors with which the body of the work abounds. About an *eighth* or *tenth* part of these notes are derived from the remarks of friends. It was at first intended to make a particular acknowledgment to every individual who had furnished any thing of this kind; but, for cogent reasons, a general acknowledgment was afterwards thought preferable.

CONTENTS

OF THE

FIRST VOLUME.

A

BRIEF RETROSPECT

OF THE

EIGHTEENTH CENTURY.

INTRODUCTION.

THE oldest historian in the world, and the only one in whose information and faithfulness we can place unlimited confidence, tells us, that, in the beginning, when God created the heavens and the earth, he said—*Let there be lights in the firmament of the heaven, to divide the day from the night; and let them be for signs, and for seasons, and for days, and for years.* Without recurring to the regular motions of these celestial orbs, time would pass unnoticed and unmeasured. Its flight, in itself, is not an object of sense; we neither see nor hear it. But by observing the diurnal revolutions of the heavenly bodies, we acquire the conception of days; by dividing these days, we form hours and minutes; and, by multiplying them, we gain the ideas of months, years, and ages. Like all the rest of the works and ways of God, these means of marking the progress of time, and ascertaining its portions, are adapted to promote both physical and moral advantage. To the phi-

losopher they furnish inestimable rules and principles of calculation; to the man of business they present measures and stimulants to industry; and, above all, to the christian they offer continual memorials of the end of life, and unceasing excitements to moral dispatch.

Hence the close of one year, and the commencement of another, are generally marked by mutual congratulations, by a peculiar train of reflections, by new plans and undertakings, and by characteristic changes in domestic, social, and political affairs. It is a period which interests the feelings, and constitutes a prominent point in the life of almost every man.

But, on reaching the termination of an active and eventful CENTURY, and entering upon a new one, the emotions of the reflecting mind are still more strong, and the impressions made more various and interesting. This is a transition which few individuals at present on earth have before witnessed, and which few now living will ever again behold. At such a period it is natural, and it is useful, to pause; to review the extensive scene; to estimate what has been done; to inquire whether we have grown wiser and better, or the reverse; and to derive those lessons of wisdom from the whole, which rational beings ought ever to draw from experience.—While the student of chronology is disputing about the time when the old century terminated, and the new one began;[a] and while

[a] It would be neither convenient nor seasonable to attempt, in this place, a discussion of the question, when the nineteenth century commenced. The author takes for granted, that it commenced on the first day of January, 1801. In this opinion he is supported by the decision of many of those who are best qualified to judge on the subject. DE LALANDE, the great French aftronomer, tells us that the same question was discussed with great warmth at the close of the seventeenth century, and that many pamphlets were written with a view to settle it, of several of which he is possessed. He decides, without hesitation, that the century commenced on the day above-mentioned.—*See De Lalande's History of Astronomy for* 1799.

the astronomer sees nothing in this period but the completion of a certain number of planetary revolutions, and the commencement of another series, the man of true wisdom is employed in attending to other objects, and in pursuing different inquiries.—Rich were the stores of instruction, and great the improvement, which an ancient king received from *returning, after a long course of action, and looking upon all the works which his hands had wrought, and the labour which he had laboured to do.* It was upon this calm retracing of his steps, that he discovered, more fully than ever before, wherein he had been profitably employed; and in what respects his unwearied exertions had been but *vanity and vexation of spirit.*

Standing, therefore, as we do, upon the threshold of a NEW CENTURY, it may prove both amusing and instructive to take a hasty retrospect of that to which we have just bidden adieu. In this retrospect, the scene which lies before us is large and various. On whatever part we cast the eye, important objects, and interesting lessons, present themselves to view. Out of these it will only be possible to select a few of the most conspicuous and striking, and to display each with the utmost brevity.

He who attempts to take a view, even the most superficial, of human nature, and of human affairs, within any given period, will soon find that the object which he undertakes to survey, is complex and multiform. Man, always variable, and never consistent, imparts this character to every thing that he touches. To give the history of a single mind for a single day; to mark with justice its revolutions, its progress, its acquirements, and its retrocessions; to form an estimate of the good, or of the evil, which, within this time, it may have produced; and to trace, in accurate lines, wherein

its character on that day differed from its character on the preceding, is a task which can appear easy only to ignorance and inexperience. And in proportion as the number of minds to be contemplated increases, or the length of the time in question is extended, the difficulties of the undertaking multiply, and it becomes, in every respect, more arduous. How numerous the difficulties, then, of estimating the operations and the progress of the human race for an hundred years!

Another source of doubt and mistake also arises here, besides that which is occasioned by the complexness and confusion of the scene. Who can distinguish between *revolution* and *improvement* in human affairs? Who can undertake to say in what cases they are synonymous terms, and when they are directly opposite? If every change were to be considered an advantage, it would follow, of course, that the strides of civilized man, in every species of improvement, during the last century, have been prodigious. But, alas! this principle cannot be admitted by the cautious inquirer, or the friend of human happiness. The passion for novelty and change, so universal and unceasing, has doubtless oftentimes indulged itself at the expense of real good, and substantial enjoyment.

A wise man, and an inspired writer, has told us, that *there is no new thing under the sun. Is there any thing whereof it may be said, See, this is new? It hath been already of old time, which was before us.*—This passage, like many others of a similar kind, is doubtless not to be interpreted as declaring literally, that there never have been, nor ever can be, any schemes, events, or discoveries entitled to the appellation of *new;* but as teaching us, in a strong and figurative manner, that the projects and improvements of human genius are frequently sinking into forgetfulness, and rising

again; that old systems are daily revived, clothed in new dresses, decorated with new names, and palmed on the world as creatures of modern birth; and that very few of the boasted efforts of genius, either in Solomon's days, or at any subsequent period, could be called entirely original. The smallest acquaintance with history is sufficient to convince any one that this is a just representation. That there are some things peculiar to certain periods and countries, will not be disputed; but that these are fewer in number, and the peculiarity much smaller in degree, than transient observers imagine, is certainly also true. Hence arises a further difficulty in deciding wherein one age differs from another. History is not an instructress sufficiently minute and patient to enable us always to judge promptly and accurately on this subject.

"It affords some astonishment," says a late writer, "and much curious speculation, to the re-"flecting mind, that, probably, not a system of "philosophy exists among the moderns, which had "not its foundation laid upon some one opinion or "another of the ancient theorists, and the outlines "of which may not be found in such of their writ-"ings as have come down to our time. Even the "Newtonian doctrine of gravitation was not un-"known to *Lucretius;* for that poet, in his first "book, attempts to refute the idea that the uni-"verse had a centre, to which all things tend by "their natural gravity. That the central point "had the strongest power of attraction was equally "an hypothesis of Sir ISAAC NEWTON and the an-"cient stoics."[b] The ingenious writer might have extended his remark much further, and have gone into a very amusing detail on this subject. Some facts, tending to confirm his position, will appear in

b DRAKE's Literary Hours, vol. i. p. 12, 13.

the following pages.[c] Let us beware, however, of carrying the principle beyond due bounds.

A difficulty also arises, in attempting to make the proposed estimate, from the disposition of man to magnify present objects. It is an old remark, that important persons and scenes acquire an additional magnitude in our eyes when seen from a distance. But it is as true that the same error of intellectual vision occurs daily with respect to objects seen near at hand. Men have always been unduly disposed to consider their own times as distinguished, above all others, by remarkable events. The virtue or the vice, the knowledge or the ignorance, the discoveries or the destructions, which we personally witness, or of which we have recently heard, are apt to impress us more deeply, and to be estimated more highly in the history of man, than their real importance deserves. Hence nothing is more common than to hear men express an opinion, that the country and the period in which their lot is cast are more awfully *degenerate*, or more extensively *enlightened*, according to the occurrence, or the object which happens to occupy their minds, than the world ever before witnessed. No doubt a portion of this prejudice and partiality cleaves to every mind, and must always interpose an obstacle in the way of him who would accurately calculate the magnitude, and justly exhibit the features of recent events.

But, after making every allowance for errors in calculation which may arise from these several

c Those who wish to see this subject farther elucidated, may consult a very amusing work of M. DUTENS, entitled *Origine des Decouvertes attribuees aux Modernes, &c.* 4to. published a number of years ago. And although the impartial reader will frequently perceive that the author carries his determination to withhold from the moderns the credit due them, for many discoveries, to an extravagant and ridiculous length, yet the work undoubtedly contains much instructive and valuable matter.

sources, it will probably be acknowledged, that the century of which we have just taken leave has produced an unusual number of revolutions, and at least some improvements,—In LITERATURE and SCIENCE—in POLITICAL PRINCIPLES and ESTABLISHMENTS—in the MORAL WORLD—and in the CHRISTIAN CHURCH.

To think of surveying each of these wide fields, throughout its whole extent; and especially to think of conducting the survey with the minuteness of observation, and the profundity of research which would become a philosophic inquirer, are, at present, out of the question. Had the writer temerity enough to engage in such a plan, or the presumption to assume so high a character, the variety and immensity of the task would soon convince him of his error. The most brief and rapid sketches only will, therefore, be attempted, on each of the above heads of inquiry.

PART FIRST.

ON THE REVOLUTIONS AND IMPROVEMENTS IN SCIENCE, ARTS, AND LETTERS, DURING THE EIGHTEENTH CENTURY.

IT is justly remarked by an acute modern writer,[d] that the history of learning and science is much less uniform than that of civil affairs; that the wars, negociations, and politics of one age more resemble those of another, than the literary and scientific taste. He explains this obvious fact by observing, that, in public and political transactions, ambition, honour, malice, revenge, and the various turbulent passions of man, are the prime movers; and that these passions are not only the same in every age, but are also stubborn, intractable, and by no means susceptible of the same variety of modification which frequently takes place in the literary taste and habits of different times. The former we can scarcely expect any thing human to controul; but the latter may be and are every day affected by education, by example, and by a thousand circumstances which it would be difficult to enumerate.

It has often been made a question whether mankind have effected any real progress in knowledge, during the eighteenth century. There are not a few who maintain the negative; who contend, that although this period has been abundantly productive of new theories, specious plans,

d HUME's Essays, vol. i. p. 110.

and *oppositions of science falsely so called;* yet that little, if any thing, has been done toward the cultivation of solid learning and real science, since our fathers of the seventeenth century fell asleep. In the opinion, and in the language of such, the present race of men are "a generation of triflers "and profligates, sciolists in learning, hypocrites "in virtue, and formalists in good breeding; wise "only when they follow their predecessors, and "visionary fools whenever they attempt to deviate "from, or go beyond them." With these cynical critics novelty is degeneracy; and every thing which bears the name of invention, discovery, or improvement, is useless, if not dangerous innovation. But this indiscriminate opposition to the claims of modern times is evidently rather dictated by prejudice than by enlightened views and impartial observation. Though a change of circumstances may produce different degrees or kinds of excellence in the efforts of intellect; yet the native powers of man are doubtless the same in all ages. It must be admitted, indeed, that in some of the branches of human knowledge the last age has added nothing to the attainments of the preceding; and that many things which superficial readers consider as new, were long since familiarly known, and as well practised as at the present day. In works of genius, imagination, and taste, there seems no good ground to represent the present generation as possessing any peculiar or transcendent excellence. Perhaps a candid inquirer would even say, that in these respects we rather fall below than rise above the standards of former times, and for this fact plausible if not satisfactory reasons may be assigned. But still, amidst multiplied false theories, and much pompous jargon, which have been too prevalent in the world during the last century; though the field of

enterprise, in this department of human exertion, has been more remarkable for the number of labourers employed in it, than for the success of their labours; though luxuriant foliage, more than substantial fruit, has abounded; yet much, within this period, has been done. New and important truth has been elicited: discoveries of an highly interesting nature have been made: systems of philosophy have assumed a more regular, consistent, and dignified form: and various departments of learning have been purged of the dregs, and rescued from the rubbish with which the ignorance and the inexperience of former times had encumbered them.

At the close of the seventeenth century, the stupendous mind of NEWTON, and the penetrating genius of LOCKE, had laid their systems of *matter* and of *mind* before the world. Like pioneers in an arduous siege, they had many formidable obstacles to remove—many labyrinths to explore—and the power of numberless enemies to overcome. But they accomplished the mighty enterprise. With cautious, but firm and dauntless step, they made their way to the intrenchments of fortified error; they scaled her walls; forced her confident and blustering champions to retreat; and planted the standard of truth, where the banner of ignorance and of falshood had so long waved.

It cannot be supposed, indeed, that these great men taught *nothing but the truth*, and far less that they taught the *whole truth*. They were fallible mortals. They were liable to err. They did err. But their achievements in the respective regions of knowledge which they explored and cultivated, were so splendid, as to command the admiration not only of their countrymen and contemporaries, but of the civilized world, and of posterity. Besides all the light which they in-

dividually threw on the departments of science which they undertook to investigate, each commenced, or rendered fashionable, a mode of philosophizing in his particular sphere, equally new, grand, and interesting; and they may be said to have laid the foundation of all the magnificent structures which have been since erected.

To Newton no successor has hitherto appeared. The chair which he left has never since been filled. It is probable no effort of the human mind, to rear a rational and permanent system of philosophy, was ever attended with such a degree of success as that which he made. Certainly no other system ever attained such extensive and undisputed empire in science. It is founded on principles so precise, connected and firm; it explains, with such luminous clearness, most of the phenomena of the heavens which had been observed before his time, as well as of those which the persevering industry, and the more perfect instruments of later astronomers have made known; and instead of being undermined or discredited, has been so remarkably illustrated and confirmed by the labours of subsequent inquirers, that any thing like efficient opposition seems to have been long since given up; and the admiring world appears no longer to hesitate in placing the discoveries of this wonderful genius among the most important that were ever made by man, and among the very few which may justly lay claim to immortality.

And if the intellectual system of Locke have gained a sway, less general and potent, than the physical doctrines of his great contemporary; still, perhaps, his genius ought to be considered as but little inferior. What though a few respectable metaphysicians, since his day, have pointed out some errors in his principles, and suggested some valuable improvements in his philosophy of mind?

They were taught by him to think and to reason. They stood on ground which his wisdom and diligence had gained. As long as the human faculties continue to be objects of study, this illustrious man must be considered one of the greatest fathers of knowledge, and his writings as forming a distinguished æra in the history of science.

But though no builders in the temple of science may have arisen to the same rank with those MASTER WORKMEN, whose names have been mentioned; yet many distinguished men, within the period of which we are speaking, have contributed their labours to enlarge, to simplify, to strengthen, and to adorn the edifice, with honourable success. Of these, time would fail us to recount even the principal names. The most general and superficial views only of their laudable achievements can be given.

CHAPTER I.

MECHANICAL PHILOSOPHY.

UNDER this general head is included the whole of that extensive branch of science, "which explains the sensible motions of the bodies of the universe, with the view to discover their causes, to account for subordinate phenomena, and to improve art." In this department of science, the progress of the last century has been astonishingly great. New fields of inquiry have been opened; splendid discoveries have been made; and facts, apparently discordant, have been connected and systematized, to an extent which does signal honour

to human capacity; and which far surpasses what the most sanguine projectors of former times had reason to anticipate. And the paths to yet further improvements in this science are so clearly marked out, that nothing seems requisite but honest industry, patience, and persevering attention, to enable future adventurers to penetrate into regions of knowledge, at present far removed from the sight of man.

Though the Newtonian Philosophy is, perhaps, one of the noblest products of human genius ever given to the world; yet that great interpreter of nature was by no means free from mistake, which besets, and characterizes all human labours.—The errors in this system, which probably, all things considered, were as few as ever mingled themselves with so extensive and important a fabric, were, some of them, corrected by his successors; who, while they could distinguish spots in this luminary of science, yet were not backward to pay due homage to his general and splendid excellence.—But, though he had many philosophical adversaries, who called in question his right to the honour of certain discoveries, and who opposed particular doctrines, there were few who ventured to declare war against the leading principles of his system. This however was done by some, respectable both for their learning and talents.

Among these, perhaps none are more worthy of notice than the celebrated JOHN HUTCHINSON, of Great-Britain, and his followers, who occupy a considerable space in the scientific history of the eighteenth century. Mr. HUTCHINSON, dissatisfied with the prevalence of Newton's opinions, and, perhaps, feeling some envy at his extended fame, undertook to disprove the doctrines displayed in his *Principia*, as opposed to revelation, and, of consequence, false. To effect this, he

published, in 1724, the first part of a large and learned work, which he called *Moses's Principia*, in which he ridiculed the doctrine of gravitation as impious and absurd; and in 1727, the second part, in which he delivered what he supposed to be the true principles of scripture philosophy. This singular philosopher taught, that the sacred writings are intended to instruct us in all physical as well as moral and spiritual truth; that the Hebrew text of the Bible is not only, in every respect, entire, as it came from God; but also that every word of it is pregnant with philosophical, as well as theological meaning. Hence his hypothesis is chiefly founded on arbitrary and fanciful interpretations of Hebrew words, from the hidden meaning of which he and his followers supposed themselves to have drawn the richest stores of various kinds of knowledge.

According to HUTCHINSON, "all things are con-"tained in the substance of God, and his substance "extends to infinite space. Heaven and earth, "space and matter, are created things, and con-"sist of solid atoms; those of earth adhering in "bodies or dense fluids—those of the heaven in "orbs, darkness, fire, light and clouds. The uni-"verse is *full* of these solid atoms: in other words, "creation is a *plenum*. The matter of the heavens "is fluid; it is also finite, and has circumferential "limits or extremities, though it extends through "all created space, from the sun, its centre, be-"yond the remotest fixed stars. This matter of "the heavens consists of *spirit*, or *air*, *light* and "*fire*, as three of its principal modifications. The "sun is the fire-place which sets all this matter in "motion, melting, expanding, and throwing it "off to the most distant confines of creation, where "it is cooled, consolidated, and pressed back "again, to be melted anew, and sent forth a se-

" cond time; and so on. The solid atoms are of " different sizes and figures; so that, when one " portion of them congeals, or forms into grains, " there are pores among them large enough to " permit atoms of a smaller size to pass freely " through. The condition of the matter of the " heavens, under the action of fire at the sun, was " *chamah;* the streams of light from the sun, moon " and stars, were *ashteroth;* and the grains of air " returning from the circumference of the heavens " to the sun, was *baalim.* Concrete matter, how-" ever, is often so constituted as not to be perme-" able very easily, but to resist. The several sorts " of atoms composing the fluid matter which oc-" cupies immeasurable space, are the moving " powers by which God acts upon and regulates " the machinery of the universe. The more com-" pact or unyielding modifications of it constitute " the great orbs, or machines, to be urged along " by their impulse. The latter are the *chariots,* " and the former the *drivers.* When, therefore, " light, impelled by the sun, strikes the side of " such a body as the earth we inhabit, it excites " heat in that part, and the spirit, or air, being " rarefied, or made to recede thereby, motion is " communicated to the whole orb. The motion " thus begun, is promoted and continued by the " vast and incessant pressure of the dark, cold " and dense matter on the opposite side. And " thus the globe being started by the lessening of " pressure on one side, and the augmentation of it " on the other, its diurnal and annual revolutions " were soon impressed upon it by a little variation " of the forces. The like reasoning he applied to " the moon, and to all the other planets and their " satellites. By the operation of light, thus sent " out from the sun, and acting upon the other fluid " matter of the heavens, and upon the celestial

"orbs, they become enlightened, warmed or in-"flamed: spirit, or air, pushed in with irresisti-"ble compression; and motion, rotation and pro-"gression were accounted for, without having "recourse to such miserable terms as projection, "gravitation, or attraction."[e]

These wild and fanciful opinions attracted much attention in Great-Britain, and were embraced by some learned and respectable men; especially by those who entertained the groundless fear that NEWTON's system of philosophy was hostile to revelation. Among these the celebrated PARKHURST, Bishop HORNE, and the Rev. Mr. JONES, of Nayland, were, perhaps, the most able and distinguished.—But notwithstanding the weight of a few names, which appeared on the side of this hypothesis, before the close of the eighteenth century, it had lost a large portion of its advocates; and both the admiration and the knowledge of HUTCHINSON's voluminous writings had nearly disappeared.

Another opponent of the Newtonian system was GODFRED WILLIAM LEIBNITZ, a philosopher of Leipsic, in Germany, whose celebrated theory demands our notice. He taught that the whole universe is made up of *monads*, that is, simple substances without parts or figure, each of which is, by

e After examining, with considerable care, HUTCHINSON's Works, in 12 vols. 8vo. printed in 1748, I did not dare to undertake the arduous task of exhibiting the opinions scattered through his erudite but obscure pages, in a short compass, and in my own language. I have therefore taken the above abstract from the Medical Repository, vol. iv. p. 281, 282. Those who wish to obtain a farther knowledge of the peculiar notions of this singular man, without the trouble of wading through his dull and tedious volumes, will find a tolerably distinct and comprehensive account of them, in *the State of the Republic of Letters*, &c. vol. v. for the year 1730 —And in a work entitled, *Thoughts concerning Religion*, &c. printed at Edinburgh, 1743. It is curious to observe, that while the *Hutchinsonians* so liberally censure the followers of NEWTON for giving too much *activity* to *matter*, they fall into the same error (as they call it) in an equal degree. But, in truth, if NEWTON's idea of *attractive power* be examined, it will be found only another mode of expression for *a continual Divine agency*, exerted *according to a certain law.*

the Creator, in the beginning of its existence, endowed with certain active and perceptive powers, sufficient to produce all the changes which it undergoes, from the beginning to eternity; which changes, though they may seem to us to be the effects of causes operating from without, are only the gradual and successive evolutions of the monads own internal powers, which would have produced the same motions and changes, although there had been no other being in the universe. He supposed, farther, that the universe is completely filled with monads, without any chasm or void, and thereby every body acts upon every other body, according to its vicinity or distance, and is mutually reacted upon by every other body; hence he considered every monad as a kind of living mirror, which reflects the whole universe, according to its point of view, and represents the whole more or less distinctly. The adoption of this visionary system led LEIBNITZ to oppose, with considerable warmth, several of the leading doctrines of NEWTON, and especially his great principle of gravitation. The hostility of the German philosopher toward the illustrious Briton, was particularly displayed in his controversy with the learned and acute Dr. SAMUEL CLARKE. The papers which gave rise to this controversy, together with the various answers, replies, and rejoinders which took place in the course of it, were transmitted from the one party to the other, through the hands of Queen CAROLINE, consort of GEORGE I. and the patron and correspondent of LEIBNITZ. They were afterwards published, and hold an important place in the philosophical history of the age.

Soon after the theory of monads was published, CHRISTIAN WOLFE, a philosopher of Breslau, formed, on the foundation of this theory, a new system of *Cosmology*, digested and demonstrated

in a mathematical method. He was one of the most voluminous writers in philosophy which the century afforded, and is considered as the great interpreter and advocate of the Leibnitzian system.

Another *theory of matter*, which distinguished the eighteenth century, was that of Father BOSCOVICH, a learned Jesuit of Italy.—NEWTON paid little attention to the individual atoms of which matter is composed. The attraction and repulsion of which he spoke, appear to refer chiefly to the laws of motion of the larger bodies which we behold. He expressed a suspicion, indeed, that "As the great movements of the solar system are "regulated by universal gravitation; so the mutual "actions of the particles of matter are produced "and regulated by tendencies of a similar kind, "equally, but not more inexplicable; and the "principles of which are to be discovered by as "careful an attention to the phenomena, and by "the same patient thinking which he had em-"ployed on the planetary motions." But he seems to have willingly yielded to some able and diligent inquirer who should come after him, both the labour and the honour of exploring this extensive field of speculation.

Such an inquirer was the illustrious BOSCOVICH, a man equally distinguished for the purity of his moral and religious character, the depth of his erudition, and the native vigour and acuteness of his mind. A few years after the death of the great British philosopher, he published a new *theory of matter*. In this theory, the whole mass of which the bodies of the universe are composed, is supposed to consist of an exceeding great, yet finite, number of simple, indivisible, inextended atoms These atoms are endued by the Creator with *repulsive* and *at-*

tractive forces, which vary according to the distance. At very small distances the particles of matter repel each other; and this repulsive force increases beyond all limits, as the distances are diminished; and will, consequently, forever prevent actual contact. When the particles of matter are removed to sensible distances, the *repulsive* is exchanged for an *attractive* force, which decreases in an inverse ratio with the squares of the distances, and extends beyond the sphere of the most remote comets. Besides these repulsive and attractive forces, the particles of matter have that *vis inertiæ* which is admitted by almost all modern philosophers. These atoms, endued with these forces and properties, form the basis of this celebrated system—a system unquestionably among the most remarkable that have been proposed to the world in modern times, and which leads to consequences in a very high degree interesting. This system has been, in substance, adopted by many of the learned in various parts of Europe; and is supposed, by those who embrace it, to afford a very satisfactory solution of many difficulties to which former theories evidently gave rise; to explain most happily the various phenomena of matter to which its principles extend; and to receive confirmation by the experiments and discoveries of every day. If we may rely on the doctrines of the ingenious Italian, the stumbling blocks of the *infinite divisibility* and *impenetrability* of matter will be taken out of the way; many of the most fruitful sources of perplexity and dispute respecting *extension*, *elasticity*, &c. will be cut off; a large portion of the difficulties attending the *affinities*, *attractions* and *combinations* in chemical philosophy, hereafter to be noticed, will diminish, if not disappear; and the path to a just under-

standing of all the physical sciences will be simplified and smoothed to a most pleasing degree.[f]

But besides these new theories, and ingenious discussions, respecting the general principles and properties of matter, almost all the particular departments of mechanical philosophy have been investigated with great diligence and success, throughout the whole of the period under consideration.

ELECTRICITY.

Concerning Electricity, that powerful and still mysterious agent, the philosophers of the last age have made splendid discoveries. At the beginning of the eighteenth century, this branch of science could hardly be said to have a place in systems of philosophy. Its phenomena had been so little the subject of experiment, and its laws had been so little comprehended or methodized, that scarcely any thing which deserves the name of theory, on the subject, was then presented to the world. It is true, a number of facts were then known, and some experiments had been made, in order to elucidate this dark recess of science. But they were known, for the most part, only as insulated facts, without any correct idea of the relation subsisting between them, or of the general principles upon which they depended. The principal of these facts had been brought to light by Dr. GILBERT, Mr. BOYLE, and Sir ISAAC NEWTON;

f The author has never yet been able to procure a copy of the *Theoria Philosophiæ Naturalis* of BOSCOVICH, published in 1758; but a very satisfactory abstract of the work is given in the *Supplement* to the *Encyclopædia*, lately published by Mr. Dobson. The system is, in some of its parts, so intricate, and throughout so involved in mathematical calculation, that a more full account of it could not be given in the present sketch. It is charged, by some, with having an *atheistical* foundation and tendency. Of the ground of this charge too little is known by the writer to attempt a discussion of it.

but they continued to lie in uncertainty and confusion, until 1709, when Mr. HAWKSBEE, an English gentleman, wrote on the subject, and distinguished himself by the experiments and discoveries which he announced. He first took notice of the great electric powers of *glass*, together with a variety of phenomena relating to electrical attraction and repulsion; insomuch that his writings and experiments form a grand æra in this branch of knowledge. From the time of Mr. HAWKSBEE's publication, near twenty years elapsed before any farther discoveries or improvements were suggested.

In 1729, the fundamental distinction between *conductors* and *non-conductors* was first ascertained by STEPHEN GRAY, a British philosopher, who had for some time before amused himself with electrical experiments, and who was now accidentally led to the discovery of this important principle. Soon afterwards M. DU FAY, member of the Academy of Sciences at Paris, in repeating Mr. GRAY's experiments, unexpectedly perceived, for the first time, that difference in the attractive powers of different bodies, which he supposed to arise from two different species of electric fluids, and which he denominated the *vitreous* and *resinous* electricities. The drawing a spark from the living body was also first observed by this gentleman, and his companion, the Abbé NOLLET. The next person who distinguished himself in this part of science was Dr. DESAGULIERS, who, though he added but little to the knowledge before possessed, yet made some valuable experiments, and invented some *technical terms*, such as *conductor*, *electric per se*, *&c.* which have proved highly convenient, and are still in use. About 1742 electricity began to excite attention, and became the subject of much inquiry in Germany. Professor BOZE, of Wittem-

burgh, and professor WINCKLER, of Leipsic, invented several improvements in the apparatus for conducting experiments. Dr. LUDOLF, of Berlin, first succeeded in setting fire to inflammable substances, by the electric fluid; and Mr. WAITZ, Mr. ALLAMAND, and others made some new observations, though chiefly of the smaller kind. To the experiments in Germany succeeded those of Dr. WATSON, in Great-Britain. He first ascertained that the friction of an electric did not *produce*, but only *collected* the mysterious matter which wrought such powerful effects; and also made a number of other interesting additions to the knowledge before existing on the subject. The year 1745 was distinguished by a discovery still more remarkable and important than any that preceded it; viz. the method of giving a shock, by accumulating the electric fluid in a jar, and discharging it by means of a conductor. This discovery was made by Mr. VON KLEIST, dean of the Cathedral in Camin; and the next year the experiment being repeated, in a different manner, and with better success, by Mr. CUNÆUS, of Leyden, the jar so filled became generally known by the name of the *Leyden Phial*, which it has retained to the present day. Soon afterwards, Mr. GRALATH, a German, first contrived to increase the shock by charging several phials at the same time, and making what is now called a *battery*.

About the same time experiments began to be made of the effects produced by electricity on *animal* bodies. In these inquiries the Abbé NOLLET greatly distinguished himself. He pursued his investigations with singular ingenuity, labour, and expense; and opened a new and noble field of electrical discoveries. The application of electricity to growing *vegetables* was first made by Mr. MAIMBRAY, of Edinburgh, who found that,

in certain cases, it expedited the progress of vegetation. In these experiments he was followed by the Abbé NOLLET, M. JALLABERT, of Geneva, Mr. BOZE, before mentioned, and a number of others on the continent of Europe, who all drew the same conclusions.

In the midst of the general attention, and the deep interest which this subject now began to excite, throughout the philosophic world, Dr. FRANKLIN, in 1752, after having been for some time engaged in making new and interesting experiments, discovered the *identity of the electric fluid and lightning;*[g] a discovery of the greatest practical utility; and, perhaps, the only one in the science under consideration, which was the result of preconceived opinion, and of experiments instituted with an express view to ascertain the truth. Dr. Franklin's ideas were soon afterwards confirmed by Messrs. DALIBARD and DELOR, of France; who had come to a similar conclusion before they were informed of what had been done on this side the Atlantic. The same illustrious American also first discovered, in conjunction with his friend Mr. THOMAS HOPKINSON, the peculiar power of *pointed bodies*, to draw off the electrical matter, more effectually, and at a greater distance than others; founded on which, was his ingenious invention for defending

g There are persons who believe, but probably without sufficient foundation, that this fact, and several others, relating to electricity, generally supposed to be modern discoveries, were known to the ancients. Those who wish to see this opinion ingeniously and learnedly defended, will be gratified by a perusal of M. DUTEN's work, before quoted; and also, an interesting paper in the *Memoirs of the Literary and Philosophical Society of Manchester*, vol. iii. by WILLIAM FALCONER, M.D. F.R.S. To which may be added a curious passage in Signor BOCCALINI's *Advertisements from Parnassus (Century* I. *Chap.* 46.) published more than one hundred years before the date of Franklin's discovery. For a reference to this passage, I am indebted to the Rev. Dr. NISBET, President of Dickinson College, Pennsylvania; a gentleman, whose profound erudition, embracing the literature and science of almost all cultivated languages, is well known to the public; and with whose friendship I consider it one of the most happy circumstances of my life to be honoured.

houses from the destructive effects of lightning, by the use of *metallic conductors*. About the same time, Dr. Franklin's friend, Mr. Kinnersly, distinguished himself by rediscovering the apparently contrary electricities of glass and resin, or sulphur, which M. Du Fay had long before observed, but with whose discovery he and Dr. Franklin were both unacquainted. To solve the difficulty arising from this fact, the Doctor, instead of recurring to the supposition of two different *kinds* of electric matter, as the French philosopher had done, proposed his celebrated theory of *positive* and *negative* electricity, or the *plus* and *minus* states of bodies charged with that fluid: a theory which had been before suggested by Dr. Watson, and which was afterwards generally received throughout the scientific world; and, though by no means without opposition, still continues to hold a more extensive influence than any other.

Electricity seems to have been first applied to *medical* purposes, by Mr. Kratzenstein, Professor of Medicine at Halle, in 1744. From that period it gradually grew into notice, by means of the experiments of the Abbé Nollet, Jallabert, of Geneva, Sauvages, of Montpellier, Bohadsch, of Prague, Dr. Watson, before mentioned, Dr. Franklin, and many others. The medical virtues of this wonderful fluid soon excited attention and inquiry throughout the scientific world. And although the repetition of experiments, which has been constantly going on from that period to the present, has served to correct many errors into which the enthusiastic fell in the beginning; yet electricity, after undergoing many revolutions of fashion, is now well established as an important article of the *Materia Medica*.

After the interesting discoveries of Dr. Franklin, the next great experimenters and discoverers

in electricity were Mr. CANTON, of Great-Britain, Signor BECCARIA, of Italy, and Mr. WILCKE, of Germany, who considerably enlarged the sphere of our knowledge respecting the conducting powers of different substances; and threw farther light on the *plus* and *minus* states of electrics. The doctrine of FRANKLIN, that these two states arise from a redundancy or deficiency of the same matter, was but little opposed, until 1759, when Mr. SYMMER, an English philosopher, revived the ideas of DU FAY, with some new modifications of his own. He taught the existence of *two electric fluids*, not independent, but always co-existent, and counteracting one another. In this opinion he has been followed by some gentlemen of very respectable character, in Great-Britain, and on the continent of Europe; though by far the greater number of the learned appear still to be in favour of the *Franklinian* theory.[h]

The progressive improvements of electrical *machines*, and of the various instruments for exhibiting the phenomena of this science, have generally kept pace with the gradual developement of its principles. Hence the honour of these improvements is, in general, due to the gentlemen already named. Beside these, several artists of respectable character have done much to forward the mechanical part of this branch of philosophy.

Soon after the grand discoveries of Franklin, Mr. ÆPINUS, a philosopher of high character in the Imperial Academy of St. Petersburgh, assuming his principles, offered to the world some new and interesting views on this branch of science. Struck with the resemblance between the phenomena of electricity and magnetism, and believing that the

h The above stated facts relating to the rise and progrees of electricity, are chiefly taken from Dr. PRIESTLEY's *History of Electricity*, 1794, London, 4to.

attractions and repulsions of each might be reduced to regular and similar classes, he attempted to throw the laws of both into a perfectly systematic form, and to introduce the most precise mathematical calculations into regions which were before supposed, from their indefinite and mysterious character, least of all susceptible of being explored in this manner. It is believed by many, that this hypothesis, to the unquestionable claim of ingenuity, adds that of being founded in truth; and that it will probably lead to the solution of many difficulties, hitherto deemed insolvable. However this may be, it must be confessed the ingenious Russian has enabled us, by his mathematical principles, to class many of the phenomena of which he treats, with a most plausible precision, and to predict the result of proposed experiments with very pleasing success.[i]

During the last thirty years of the eighteenth century, though it cannot be said that so much has been done in electricity as in the like period immediately preceding; yet several important discoveries, within that time, have been announced. The inventions of the *Electrophorus*, and the *Condenser* by professor VOLTA, and of the *Doubler* of electricity, by the Rev. Mr. BENNET, of Great-Britain; the discovery of the effects produced by the electric matter on permanently elastic fluids, and on water, by Mr. CAVENDISH, and others; and the correction of former errors, with respect to the influence of electricity on vegetables, by Dr. INGENHOUZ, may be considered among the most interesting of recent improvements.[j] Mr. CAVEN-

i See *Theoria Electricitatis et Magnetismi*, 1759, Petersburgh, 4to. See also a good abstract of the doctrines of Æpinus, in the *Supplement to the Encyclopædia*, published at Philadelphia by Mr. Dobson.

j For a more full account of the above recent discoveries and improvements, see the last vol. of *Cavallo*'s Electricity, 3 vols. 8vo. edition 1795. and the art. *Electricity* in the *Encyclopædia*, and the *Supplement*.

DISH and Lord MAHON are the only distinguished writers on electricity, in the English language, who have attempted, like ÆPINUS, to introduce the mathematical form of investigation into this science. The publications of Dr. PRIESTLEY, Mr. CAVALLO, and Mr. ADAMS, on the subject, are also worthy of honourable notice. The first, besides his excellent *History of Electricity*, instituted a number of original experiments; suggested many important inquiries; improved the electrical apparatus; and, on the whole, did much to advance our knowledge of this branch of philosophy. The latter gentlemen, in addition to many new experiments, have presented to the world condensed and very satisfactory views of the subject, both in a *philosophical* and *medical* view, and have contributed much to render it popular and useful.

GALVANISM.

To this chapter belongs some notice of that principle or influence, discovered a few years ago, by Dr. GALVANI, a philosopher of Bologna, and since, in honour of him, denominated GALVANISM. It was first called *Animal Electricity*, a name which had been, for a number of years before, given to a remarkable property observed in several fishes, of conveying a shock, or a benumbing sensation to those who touched them.[k] But this property was always found to be extinct or dormant in such animals, immediately after their death. In 1762, SULZER, a German, in his *Theory of agreeable and disagreeable sensations*, gave some hints of a curi-

k These are the *Torpedo*, the *Gymnotus Electricus*, the *Silurus Electricus*, and a fourth, found near one of the *Comoro* islands, by Lieut. WILLIAM PATTERSON, of which an account is given in the 76th vol. of the *Philosophical Transactions*.

ous effect resulting from the junction of two pieces of different kinds of metal, and applying them, thus joined, to the tongue; but these hints seem to have been disregarded, and were soon buried in oblivion. In 1791 Professor GALVANI announced a discovery made by him, that the muscles of dead animals might be stimulated and brought into action, by means both of artificial and atmospherical electricity. He also discovered, that independent of any collection of the electric fluid for the purpose, the same action might be produced in the dead animal, or even in a detached limb, by merely making a communication between the nerves and the muscles with substances that are conductors of the electric matter.[l] GALVANI's first experiments were made on dead *frogs;* but the discovery, soon after being announced, was pursued; experiments were made on different animals; and a number of new facts, tending to show the connection between *Galvanism* and electricity, and the circumstances in which they differ, were brought to light by Professor VOLTA, and Dr. EUSEBIUS VALLI, of Italy; by M. VON HUMBOLDT, and Dr. PFAFF, of Germany: by Dr. MONRO, Dr. FOWLER, Mr. CAVALLO, and Dr. LIND, of Great-Britain; and by COULOMB, FOURCROY, SABBATIER, PELLETAN, and others, of France.

Hitherto this influence or agent had been chiefly investigated with reference to its operation on *animal* substances. Hence its popular name was, for a considerable time, *animal electricity.* But it being soon found, that its agency was more extensive; that it possessed powers not indicated by this denomination; and that of course the retention of this name would lead to error, the word *Galvanism* was adopted in its stead. This exten-

l *Aloysii Galvani de viribus Electricitatis,* &c. 4to. Bononiæ, 1791.

sion of the Galvanic principle was connected with new discoveries and improvements, from various quarters; these, however, for a considerable time, were generally small and unimportant in their nature.

But among all the recent discoveries in *Galvanism*, that made by Professor VOLTA, in 1800, is most remarkable in its nature, and most interesting in its relations. His mode of constructing a *pile*, for condensing, retaining, and communicating a perpetual current of the *Galvanic influence*, is generally known.[m] The curious phenomena which this pile exhibits; the connection which these phenomena indicate with the principles both of electricity and of chemistry; and the numerous experiments and successive improvements in the management of this Galvanic battery suggested by Professor VOLTA; by Messrs. CARLISLE, NICHOLSON, CRUICKSHANK, DAVY, and others, of Great-Britain; by VAN MARUM, of Holland; and by

m The pile of VOLTA is thus formed. Take a number of plates of *silver*, an equal number of *zinc*, and the same number,of pieces of *card* or *woollen cloth*. Let these last be well soaked in *water*, or water saturated with common *salt*, or what is perhaps still better, with *nitre*. A *pile* is then to be formed of these substances, in the following manner. A piece of zinc, a piece of silver, and a piece of wet cloth or card, are to be successively placed on each other; then another piece of zinc, and so on in the order of the first layer. In this manner, the pieces are to be arranged, or in any other manner, provided a regular alternation be observed, until the requisite number shall be laid. The instrument is then fit for use. The pieces of card should be somewhat less than the pieces of metal, and after being well moistened, should be gently squeezed before they are applied, that the superfluous moisture may not run down the pile, or insinuate itself between the pieces of metal.

The instrument constructed in this manner affords a perpetual current of the Galvanic influence; and if one hand be applied to the lowest plate, and another to the upper, a shock is felt, as often as the contact is repeated. The shock received from this pile is somewhat like that given by a Leyden phial; but more nearly resembles that given by a *Torpedo*, which animal this apparatus also resembles in giving incessant shocks. The intensity of the charge is, however, too small to make its way through the dry skin; it is therefore necessary that each hand should be well wetted, and a piece of metal be grasped in each to make the touch;—and the larger the piece of metal which is thus held in the hand, the stronger the shock. Garnett's *Annals of Philos.* vol. i. p. 10, &c.

FOURCROY, VAUQUELIN, and THENARD, of France, have not only excited much attention in the scientific world, but may also be ranked among the rich additions to philosophy, which modern times have produced.

It must be admitted, however, that little more has been done, in this new branch of philosophy, than to ascertain a number of facts, sometimes contradictory in their aspect, and generally inexplicable, without either forming a theory sufficiently fixed or luminous to satisfy the inquirer, or instructing us in what manner this principle may be applied for the benefit of mankind.[n] Professor GALVANI, and several other distinguished experimenters, have supposed the Galvanic phenomena to depend on the electric fluid. They observed that this substance seemed to move with rapidity; that it produced a sensation similar to the electric shock; that it passed with facility through metals, and other conductors of electricity; while it was stopped in its course by glass, sealing-wax, and other substances which we know to be non-conductors of the electric matter. Others, on the contrary, observing several phenomena, which were thought to be incompatible with the known laws of electricity, or inexplicable by them, have rejected this opinion, and resorted to different means of solving the difficulty.

M. FABRONI, who made a number of ingenious experiments on *Galvanism*, was the first who systematically attempted to prove that the effects which he observed arose from *chemical* causes.[o] This opinion has led to much curious investigation;

n Since the above was written, very curious information has been received from Germany, respecting the application of *Galvanism* to *medical* purposes. It appears to possess great efficacy in removing many diseases arising from nervous derangement and muscular debility.

o See Nicholson's *Philosophical Journal*, vol. iii. p. 308.

and various experiments evince that the agent in question produces, most powerfully, some effects, particularly decompositions, which have been hitherto considered as belonging to the province of chemistry alone; but the main point in dispute is yet far from being satisfactorily solved. Indeed, the wonderful apparent combination of *electrical* and *chemical* agency,[p] in the more remarkable Galvanic experiments, seems to forbid the expectation of finding an adequate solution of the phenomena in any principles yet known.—But as this subject has excited so much attention among philosophers, in every part of Europe, and as new facts will probably be brought to light every day, we may hope that the time is not very distant, when a sufficient number of facts will be arranged to form a consistent and satisfactory theory, and when this branch of knowledge will take its place among the most dignified and useful of the sciences.[q]

MAGNETISM.

This branch of philosophy, during the same period, has been an object of less attention than electricity, and of fewer speculations; probably on account of the smaller range of its phenomena, and its being less capable of popular exhibition. Still, however, it has been considerably cultivated, and has received some important improvements, since the time of Dr. GILBERT, the great father of magnetical philosophy. The number of facts con-

p The above distinction between *electrical* and *chemical* phenomena is used in accommodation to the customary division of the sciences; for it may reasonably be doubted whether *electricity*, and even *magnetism*, ought not to be considered as subjects of *chemistry*.

q For further information on this subject, see the *Supplement* to the *Encyclopædia*, art. GALVANISM. See also GARNETT'S *Annals of Philosophy*, for 1800.

cerning this mysterious kind of attraction has been greatly augmented. The points in which it resembles, and those in which it differs from electricity, have been more satisfactorily ascertained; and a nearer approach made than formerly to a systematic arrangement of the magnetic laws.

The unexpected and daring introduction of mathematical principles and demonstration into the dark regions of *electricity*, by Mr. ÆPINUS, was mentioned, in a former page, as one of the signal improvements of the last century. This ingenious philosopher has done the same in *magnetism*, and with equal success.[r] And though this subjection of the magnetic principles to the most precise and definite of all species of investigation does not appear to have led, as yet, to any extraordinary discoveries, or radical reforms in theory; yet it has been by no means without its use, and may conduct to invaluable acquisitions.

The *Mariner's Compass*, within the period in question, has been considerably improved. This important instrument, after its invention in 1302, long remained in a rude and imperfect state. But Dr. KNIGHT's discovery of the mode of making artificial magnets, about the year 1744, together with the results of some other experiments, enabled him to render the compass much more convenient and useful. To his improvements may be added the further emendations of Mr. SMEATON, and Mr. M'CULLOCH, both of Great-Britain.

The *variation* of the magnetic *needle* has been a subject of much attention and of much ingenious speculation, during the past century. The observations made by Dr. HALLEY, and published in 1701, in the form of a *variation chart*, were of

r See *Tentamen Theoriæ Magn. et Electr. Petrop.* 1759. See also the *Supplement* to the *American Encyclopædia*, by DOBSON, articles *Electricity* and *Magnetism*.

great use to navigators, and contributed not a little toward reducing the principles of this variation to something like an intelligible form. The next attempt of the same kind, worthy of notice, was that of EULER. This philosopher, equally remarkable for the extent of his learning, and the vigour and comprehensiveness of his mind, undertook, about the middle of the century, to account for the magnetic irregularities, and to ascertain the position of the needle in every part of the earth. He executed his task with singular ingenuity and perseverance; and with a plausible appearance of success. But his theory, and the whole structure founded upon it, were soon found liable to such objections, that they were considered of little value, excepting so far as they might furnish a guide in the further prosecution of the inquiry. Since the time of EULER, many others have exerted their genius in the same investigation; but without producing more certainty or satisfaction. Among the latest explorers of this dark but important subject, Mr. CHURCHMAN, a respectable citizen of our own country, deserves to be honourably mentioned. He has, in his own opinion, made valuable improvements on the theories of HALLEY and of EULER; corrected various errors into which those great philosophers fell; and given an hypothesis which bids fair to be of more practical utility than theirs to the nautical adventurer. How soon this hypothesis may be brought to the test of a complete course of experiments; or how it may bear this test, when subjected to it, are questions yet to be solved. In the mean time, the ingenuity, zeal and perseverance, evinced in Mr. CHURCHMAN's late publications on this subject, deserve the attention, the thanks, and the encouragement of the philosophic world.[s]

[s] See Churchman's *Magnetic Atlas*, 4to. 3d edition, 1800.

Many other writers, of acknowledged scientific eminence, have distinguished themselves by new experiments, and ingenious hypotheses on magnetic attraction, within the period of which we are speaking. Among these may be mentioned MUSCHENBROECK,[t] WHISTON, CELSIUS,[u] VAN SWINDEN, LAMBERT,[v] EULER,[w] KNIGHT,[x] MITCHEL, CANTON and CAVALLO. To detail the opinions entertained, and the facts successively brought to light by each, would far exceed our prescribed limits. But, after all the inquiries of these philosophers, it must be acknowledged that "clouds and darkness rest" upon this part of science; that even its general principles are little understood; and that we are yet far from being furnished with materials for a satisfactory system on the subject. Perhaps another century may accomplish this, which, when viewed in its various relations, must be regarded as a grand *desideratum* in philosophy.

In 1774 arose the idea of a certain sympathy existing between the magnet and the human body, by means of which the former might be applied to the cure of diseases. This opinion appears to have originated with Father HEHL, of Germany, who greatly recommended the use of the magnet in medicine. On some experiments and suggestions of HEHL, the famous MESSMER, a German physician, about the year 1766, erected his fanciful system of *Animal Magnetism*. The noise

t *Dissert. Physico Experimentalis de Magnete.*

u *Tentamina Magnetica*, 4to. Also *Memoirs on the Analogy between Elect. and Mag.* 3 vols. 8vo. 1785.

v The experiments and calculations of M. LAMBERT, on the *polarity* and *variations* of the magnetic needle, deserve particular attention. He was a most accurate and sagacious philosopher. See the *Memoirs of the Academy of Berlin*, for 1756, published in 1758.

w *Euleri Opuscula.* tom. iii. *Continens Theoriam Magnetis*, Berlin, 1751.

x *An Attempt to explain the Phenomena of Nature by Two Principles*, &c. 4to. 1748.

made by the opinions and arts of this celebrated empiric, and his coadjutors, in Germany, in France, and indeed, though in a less degree, throughout every other part of Europe, is well known to all acquainted with the literary history of that period; as well as the detection, the decline, and the final disgrace of them, and their principles.[y]

MOTION, AND MOVING FORCES.

This part of science also, within the century under consideration, has received no small improvement. The laws of *motion*, as laid down by Sir ISAAC NEWTON, though found, by succeeding philosophers, to be in general correct, were yet by no means perfectly so. His principles of motion in *resisting mediums*, particularly failed, when brought to the test of accurate experiment. Numerous have been the attempts to supply the defects, and to correct the errors of these principles: among which the labours of D. BERNOULLI, and of M. D'ALEMBERT, deserve to be considered as by far the most distinguished and successful. The latter in particular, in the course of his investigations, discovered a general rule, adequate to the determination of many important questions in the science of motion, and applying to the most compound and perplexing cases.[z]

The inaccuracy of NEWTON's principles, with regard to *projectiles*, was first ascertained and announced by M. RESSONS, a French artillerist, in 1716. Nothing material, however, was done toward the establishment of new and more just laws, till 1742, when BENJAMIN ROBINS, of Great-Britain, published his *New Principles of Gunnery*, a

y For an amusing account of the noise and pretensions made by MESSMER, see WILLICH's Lectures on Diet and Regimen, &c. p. 106, &c. New-York edition.

z CONDORCET on the Mind, p. 275.

very able work on the subject of projectiles, which threw much new light on this part of philosophy, and advanced a theory much nearer to perfect accuracy than had ever been given before. ROBINS was followed by his countryman Mr. C. HUTTON, who contributed to a further elucidation of the subject by a number of new and interesting experiments. After him, Mr. BENJAMIN THOMPSON, and Mr. LOVELL EDGEWORTH,[a] corrected some of the errors into which ROBINS had fallen, and considerably extended and improved his theory. In addition to the inquiries of these British Philosophers, several ingenious men on the continent of Europe contributed to the extension and confirmation of ROBINS's theory. Of this list M. D'ANTONI, of Italy, and Messrs. D'ARCY, and LE ROY, of France, are entitled to particular distinction.[b] Besides these, many experiments have been made, and valuable ideas suggested, respecting motion in resisting mediums, by GRAVESANDE, by J. BERNOULLI, by EULER, by SIMPSON, by M. BOUGUER, and by M. CONDORCET, Abbé BOSSUT, Chevaliers BUAT and BORDA, and other members of the Royal Academy of Sciences at Paris. And although this part of mechanical philosophy can scarcely be said yet to have received satisfactory elucidation; still much has been done toward the attainment of this object by the mathematicians and artists of the last age; and especially by those of France, who, in the various parts of science immediately subservient to the business of the *Engineer*, have certainly, in modern times, exceeded all the rest of the world.

The discoveries and improvements made, in the course of the last century, with respect to the con-

a *Philosophical Transactions*, vols. 71 and 73, and GLENIE's *History of Gunnery*.

b HUTTON's Mathematical Dictionary.

struction and motion of *pendulums*, are neither few nor unimportant. For the purpose of counteracting the effects produced in the dimensions of the pendulum, by heat and cold, from which disorder and error necessarily arise, the contrivances of ingenious men have been numerous and successful. For the purpose, also, of regulating the *curve* in which this body shall move, various devices and calculations have been adopted. The principal of these improvements are, the *Mercurial Pendulum*, invented by GEORGE GRAHAM; the *Gridiron Pendulum;* that formed with a rod of *baked and varnished wood;* the contrivances, by means of a *flexible rod,* and other apparatus, to make the pendulum move in the curve of a *cycloid;* to say nothing of many other ingenious inventions to regulate the motions and to extend the application of this important instrument.

In that part of philosophy which relates to the structure and motion of *machines*, many great minds have been employed, in the course of the last age, and not without making some advances in this department of science.—M. AMONTONS, of the Royal Academy of Sciences at Paris, about the beginning of the century, very successfully developed some of the general laws of machinery. After him Mr. EMMERSON, of Great-Britain, a distinguished mathematician, investigated and systematized this subject, with still more practical care and accuracy. In 1735 the celebrated EULER undertook to give a general and systematic view of machines, in order to found a complete theory, immediately conducive to the improvement of mechanics. In 1743 he published the first part of his theory, containing many new dynamical theorems of great importance.[c] He afterwards

c *Comment. Petropolitani.* tom. i.

prosecuted the subject further,[d] and with so much success, as to excite deep regret that he had not continued his useful labours. Since the experiments and publications of Euler, many philosophers of inferior name have turned their attention to the same inquiry; but without laying the scientific world under the same obligations, by exhibiting original, or very interesting views of the subject. Among these it would be improper to pass, without respectful notice, the valuable services rendered to practical mechanics by Mr. Smeaton and Mr. Bramah, both of Great-Britain. The instances of the ingenious application of mechanical principles to the construction of different machines, by which the last century is distinguished, are too numerous, and the authors of many of them too well known, to render a detailed view of them proper in this place.

HYDRAULICS.

In the principles and practice of this part of science great improvements have been made by the philosophers of the last age. To calculate upon sure and accurate grounds, the resistance and motion of dense fluids, so as to furnish a result which might be relied on by engineers, and other mechanics, was considered at the beginning of the century one of the most interesting and difficult problems in mechanical philosophy. Newton first endeavoured to reduce the laws of moving fluids to the precise form of mathematical calculation. In this, however, though he displayed great ingenuity, he was unsuccessful. His demonstrations, when tested by practice, were

d *Comment. Petrop.* tom. iii. and *Mem. Acad. Berlin*, 1747 and 1752.

found inaccurate and inapplicable. GUGLIELMINI, a celebrated Italian, succeeded him, assuming his principles, and aiming to attain the object in view by the same path. He also failed; his calculations turning out equally remote from the truth with those of his illustrious predecessor. After GUGLIELMINI, Professor MICHELOTTI, of Turin, D. BERNOULLI, of Switzerland, and the Abbé BOSSUT, of Paris, instituted many experiments, to ascertain the theory or mechanism of hydraulic motion. The last gentleman, in particular, conducted his experiments with great labour, care and perseverance, made a very important publication on the subject, and opened a path of inquiry in this field of science, so new, and in a manner so judicious, that he must always be considered as holding a high rank in the hydraulic history of the age in which he lived. After all, however, he left the subject very imperfectly explored. BOSSUT was succeeded by his countryman, the Chevalier BUAT, who took up the inquiry where the Abbé had left it, prosecuted it with singular skill and assiduity, and formed a system much nearer to the truth than all who had gone before him.—But distinguished as the Chevalier has justly rendered himself, by his achievements in this branch of philosophy, he cannot be said so much to have discovered new principles, as to have classed and systematized, with great skill and ingenuity, the principles flowing from M. D'ALEMBERT's unwearied experiments and calculations on this subject. Still the *Hydraulique* of BUAT may be considered the most ingenious, comprehensive and practical work, on the department of science of which it treats, to be found in any language. It furnishes most important information to the engineer; and enables him now to answer, with sufficient precision, many questions, in an-

swer to which little but conjecture, and that too often most mischievously wide of the truth, could be offered before. In short, the general proposition, deduced from the Chevalier's numerous facts and experiments, respecting the motion of fluids, has been pronounced one of the most valuable results of modern inquiry.[e]

Much light has been thrown, during the last century, on the doctrine of *Tides*. NEWTON was the first who gave a satisfactory explanation of this subject. But it has been remarked, that the wide steps taken by this philosopher, in his investigation, left ordinary minds frequently at a loss; and that many of his principles require very great mathematical knowledge to satisfy us of their truth. Accordingly the *Academy of Sciences* at Paris, soon after the death of the illustrious Briton, wishing to have this as well as some other parts of philosophy exhibited in a satisfactory, and, as far as could be, in a popular manner, published a prize question relative to the tides. This produced three excellent dissertations on the subject, by Mr. MACLAURIN, D. BERNOULLI, and EULER. Of these the work of BERNOULLI is considered the best, and is, perhaps, the most complete extant.[f] And it is worthy of observation, that while he threw greater light than all who had gone before him on the subject which he immediately undertook to illustrate, he furnished

e See Encyclopædia. Art. *Water Works*.

f The Abbé BERNARDIN DE ST. PIERRE, in a late work, entitled *Etudes de la Nature*, rejects the Newtonian theory of Tides, and ascribes this class of phenomena to the liquefaction of the polar ice and snow. To this amiable writer the praise of ingenuity, and of possessing a happy talent of amusing and interesting his readers, cannot be denied. Neither can it be questioned that his work contains a considerable portion of sound and pleasing philosophy. But surely this and some other of his doctrines are utterly unworthy of a mind which had been conversant with the inquiries and the writings of the great practical philosophers of the eighteenth century.

an additional and most powerful argument in support of the *Newtonian* system.

The construction of *Aqueducts* has been rendered, by the labours of modern philosophers, more simple, easy, and precise. And, in consequence of these improvements, they have, within the last century, greatly increased in number. For the valuable experiments and discoveries which have been made on this subject, we are principally indebted to the great hydraulic philosophers on the continent of Europe, whose names were before mentioned. To those names may be added the distinguished experimenters and observers, on the same subject, DESAGULIERS, BELIDOR, DE PARCIEUX, and PERRONET, who successively laboured to deduce a system of doctrines from the numerous facts before them; and whose very mistakes contributed to elucidate this obscure branch of science, which, however, is yet far from being fully understood.

Very great improvements have also been made, during the period in question, in the principles and construction of *Water-Mills*. The proper mode of adjusting forces, and calculating velocities, in this, as well as in almost every other branch of hydraulics, has long been considered among the most difficult problems in philosophy.—Mr. DESAGULIERS, early in the century, made a number of experiments on mills, and suggested some important improvements in their principles and construction. About the same time, M. BELIDOR, of France, M. BERNOULLI, and Mr. EMMERSON, of Britain, employed their great learning and talents on this subject, and made considerable progress in its illustration. These were followed by Mr. LAMBERT, of Berlin, Mr. ELVIUS, of Sweden, Professor KARSTNER, of Gottingen, M. DE PARCIEUX, before mentioned; and Messrs. SMEATON, BAR-

KER, and BURNS, of Great-Britain. To attempt an enumeration in detail of all the inventions, discoveries, and useful suggestions produced by these several philosophers and artists, would swell this account beyond all bounds. It is sufficient to say, that although that part of the science of hydraulics which relates to mills, did not arrive at absolute certainty and perfection in their hands; yet they made so many successive additions to the knowledge of preceding theorists, that to each large acknowledgments are due from the friends of human improvement. Nor ought the still later inquiries of our countrymen, Mr. WARING, on the same subject, to be forgotten. His memoir on the *maximum* velocity of a wheel or other body, moved by a given quantity of fluid, may be regarded as a singular monument of accurate and successful investigation.[g] The *theory of mills*, which he deduces from his experiments and calculations, is said to correspond with fact, to a degree greatly beyond all other attempts.[h]

The various improvements which the last century produced in the construction of *pumps*, are also worthy of notice. Since the doctrine of the pressure of the atmosphere has been reduced to a regular system, and the general laws of moving fluids have been better understood, several advantages in the formation and management of this class of engines naturally followed. Those who most distinguished themselves during the century, by inventions, or laborious investigations, on this subject, are Messrs. HADLEY, DESAGULIERS, HASKINS, and BEIGHTON, of Great-Britain, Messrs. J. and D. BERNOULLI, and WIRTZ, of Switzerland,

g See Trans. Amer. Philos. Society, vol. iii.

h Mr. WARING was an obscure character, a native and resident of Philadelphia. He belonged to the Society of Friends, and taught a school in that city. Though little known, he was a real philosopher. He died of the pestilence which raged in that city in 1793.

and Messrs. PITOT, BOSSUT, BELIDOR, DE LA BORDA, D'ALEMBERT, DE LA GRANGE, and DE BUAT, of France.

PNEUMATICS.

In Pneumatics, or that science which treats of the mechanical properties of elastic fluids, modern discoveries and improvements have been very numerous and important. Ever since the famous *Torricellian* experiment, in the seventeenth century, proved that air was a gravitating substance, the attention of philosophers has been employed, with great success, in investigating the properties, and ascertaining the laws of this fluid. By numerous and patient inquiries, they have gone far toward reducing to regular system the principles which govern the density, the weight, the elasticity, and the motions of the atmosphere. And the various mechanical properties of air, as they became, in succession, better understood, have been rendered subservient to the utility of man, by their application to the arts of life.

The *Barometer* has, within the last century, received many and most important improvements, from ROWNING, DE LUC, ROY, SHUCKBOURGH, CASWELL, NAIRNE, JONES, and others.[i] The application of this instrument to the measurement of altitudes was first suggested by Dr. HALLEY, and afterwards better explained and systematized, by several of the gentlemen just mentioned, especially by the celebrated M. DE LUC, of Geneva. The *Air-Pump*, during the same period, was much improved by HAWKSBEE, GRAVESANDE, Abbé NOLLET, SMEATON, RUSSELL, our ingenious coun-

i See Encyclopædia, Art. BAROMETER and PNEUMATICS. See also Philosophical Transactions, vol. lxxvii.

tryman, the Rev. Dr. PRINCE, of Salem,[k] LAVOISIER, and finally by CUTHBERTSON, of Amsterdam; by the last of whom, we are taught to believe, this machine has been carried to a degree of perfection beyond which little advancement is to be expected. That part of pneumatics, also, which relates to the construction of *Chimnies*, the comfort of human habitations, and the œconomy of fuel, has been, in modern times, the subject of much inquiry, and most useful improvement, by Dr. DESAGULIERS and Mr. ANDERSON, of Great-Britain, and by the illustrious Americans FRANKLIN, COUNT RUMFORD, and many others. To which may be added a number, almost countless, of wind instruments and machines, which modern ingenuity has invented, and which have grown out of our increasing knowledge of the qualities and laws of the important fluid in which we are immersed.

In this period, beyond all doubt, we are to place the invention of BALLOONS. In 1766, the Hon. HENRY CAVENDISH discovered that inflammable air (the *hydrogen gas* of the French nomenclaturists) was at least seven times lighter than common air. It soon afterwards occurred to the celebrated Dr. BLACK, that if a thin bag were filled with this gaseous substance, it would, according to the established laws of specific gravity, rise in the common atmosphere; but he did not pursue the inquiry. The same idea was next conceived by Mr. CAVALLO, to whom is generally ascribed the honour of commencing the experiments on this subject. He had proceeded, however, but little way in these experiments, when the discovery of STEPHEN and JOHN MONTGOLFIER, paper manufacturers of France, was announced in 1782, and arrested the attention of the philosophical world.

k See the Transactions of the Amer. Acad. of Arts and Sciences, vol. i.

Observing the natural ascent of smoke and clouds in the atmosphere, those artists were led to suppose that heated air, if enclosed in a suitable covering, would also prove bouyant. Accordingly, after several smaller experiments, by which this idea was fully confirmed, they inflated a large balloon with rarefied air, on the 5th of June, 1783, which immediately and rapidly rose to the height of six thousand feet, and answered their most sanguine expectations. It was soon found that machines of this kind might be so contrived as to convey small animals, and even human beings, through the air with ease. The first human adventurer in this ærial navigation was M. PILATRE DE ROZIER, a daring Frenchman, who rose in a large balloon, from a garden in the city of Paris, on the 15th of October, 1783, and remained a considerable time suspended in the air. He made several ærial voyages of greater extent afterwards, and in two of them was attended by other persons. In a short time, however, the use of rarefied air in aerostation was, for the most part, laid aside, as inconvenient and unsafe, and recurring once more to the discovery of Mr. CAVENDISH, the philosophers of Paris concluded that a balloon, inflated with inflammable air, would answer all the purposes of that contrived by the MONTGOLFIERS, and would also possess several additional advantages. They made their first experiment on the 23d of August, 1783, which was attended with complete success; and the first human beings who ventured to ascend in a balloon raised upon this plan, were Messrs. CHARLES and ROBERTS, who rose from Paris, on the 1st day of December in the same year. The inflammable air balloons have been generally used since that time; many ærial voyages have been performed in Europe and America; and what is remarkable, out of all the numer-

ous instances of such hazardous enterprize, only one is recollected, which was attended with any fatal accident.[l]

The invention of balloons, though far-famed and brilliant, cannot be considered as having hitherto added much to the comfort or utility of man. The only practical purposes which it has been made to subserve, are those of aiding in meteorological inquiries, and inspecting the fortifications, and reconnoitering the camp of an enemy, which could not be approached by other means. It has been applied to this latter purpose in at least one, if not more instances, by the French engineers, during the late war.[m] But who can undertake to assign the limits beyond which the ingenuity and the enterprize of man shall not pass? Though this species of navigation labours under difficulties which appear at present insurmountable; though the want of some means to controul and regulate the movements of the ærial vessel is so essential as to excite a fear that it cannot be supplied; yet who can tell what further experience and discoveries may produce? Who can tell but another century may give rise to such improvements, that navigating the air may be as safe, as easy, and rendered subservient to as many practical purposes, as navigating the ocean? It must be acknowledged, indeed, that this is not very probable; but things more unexpected, and more remote from our habits of thinking, have doubtless occurred.

Under this head also properly come the great improvements which have been lately made in *Steam Engines*, doubtless among the most im-

[l] There is a reference here to the death of M. Pilatre De Rozier and M. Romain, who rose in a balloon, from Boulogne, in the month of June, 1785, and after having been a mile high, for about half an hour, the balloon took fire, and the two adventurers were dashed to pieces by their fall.

[m] Gregory's Economy of Nature, vol. i. p. 515.

portant and useful kinds of machinery which human ingenuity ever contrived. The idea of making steam subservient to powerful mechanical operations, seems to have been first entertained by the Marquis of WORCESTER, in the reign of CHARLES II. of England. But little more was done, either by him, or during his time, than to speculate on the subject. It was not till the close of the seventeenth century that Captain SAVARY, an ingenious and enterprising man, actually erected several steam engines, and obtained a patent for what he considered his own invention. He afterwards improved and simplified his machines himself; but the improvements which they have undergone since the date of his, are still more numerous. For these improvements the world is principally indebted to Mr. NEWCOMEN, Mr. BEIGHTON, and above all to Mr. WATT, who, with an ardour, an acuteness, and a philosophic comprehension, which do him immortal honour, has so extended the principles of these machines, so increased their power, so successfully obviated the difficulties and inconveniences attending their operation, so accommodated their construction to peculiar circumstances, and carried the economy of steam, and, consequently, of fuel, to such an astonishing degree, that he may be ranked among the greatest mechanical geniuses and benefactors of mankind that the eighteenth century has produced.

The application of steam to the purposes of *cookery*, and of *propelling vessels* on the water, is also to be ranked among modern inventions. To the latter of these objects several of our own countrymen have paid particular attention, and with promising success. And although it must be granted that formidable difficulties have arisen in the execution of all the plans hitherto proposed, yet to doubt of the practicability of ultimately

overcoming these difficulties, can scarcely be thought either to gratify a mind of true philosophic enterprize, or to be worthy of such a mind.

Late navigators and travellers have furnished valuable materials towards forming a theory of the *winds*. It must be acknowledged that nothing entirely satisfactory has yet been offered to the world on this subject. Still many facts have been brought to light; important discoveries have been made; and from the number and talents of the gentlemen who have been for some time engaged in exploring this dark recess of philosophy, still greater advances in our knowledge of it may soon be expected. Various instruments, which answer valuable purposes for measuring the direction, the force, and the velocity of winds, have also been invented, within a few years past, by Dr. LINN, Mr. PICKERING, and others of Great-Britain. These inventions have been denominated the *Anemoscope*, the *Anemometer*, &c.

Finally, the doctrines of *Acoustics* have been very successfully illustrated, since the time of NEWTON, by various inquirers. Many facts relating to the velocity, the intenseness, and the general principles of sounds, have been established by numerous experiments. The capacity of different bodies, to propagate sound, has become better understood by the investigations of modern philosophers. Mr. HAWKSBEE, of Great-Britain, first showed that sound is propagated further in *dense* than in *rarefied* air; M. BRISSON, of France, and others, demonstrated, by various interesting experiments, that a medium more dense than air conveys sound still better than this fluid; and Dr. YOUNG, of Dublin, has, within a few years, made some new and instructive inquiries into the principles of acoustics. To which may be added the interesting experiments lately made, showing the

different intensity, and the variety of tones of sound, in different gases, by Priestley, Chladni, Jacquin, Perolle, and others.

OPTICS.

In this science great improvements have taken place in modern times. In 1704 Sir Isaac Newton first published his grand work on *Optics;* and although many of his most interesting discoveries were made and announced toward the close of the seventeenth century, yet the collection and publication of them, in a systematic form, was reserved to be one of the distinguishing honours of the eighteenth. How numerous and important these discoveries were, is generally known. He ascertained the different refrangibility of the rays of light; he made some progress in exploring the principles and laws of colours, which had been so little understood before his time; he first explained the physical cause, and laid down with mathematical precision, the general laws of the reflection and refraction of light; besides many other valuable, but less important additions to the science of optics. It must be acknowledged that his doctrines are by no means free from errors and defects; but these are few in comparison of their great merits; and have been chiefly corrected or supplied by the labours of subsequent philosophers.

Since the discoveries of Newton many important additions have been made to our knowledge of the nature and properties of *light.* The *materiality* of this substance, and the great *velocity* of its motion, were more fully illustrated and confirmed than they had been before, by Dr. Bradley and Mr. Molyneux, in 1727. A few years afterwards M. Bouguer, a celebrated French philosopher, distinguished himself by his experiments

and observations on the same substance; particularly on the laws of its reflection and refraction. On this subject, indeed, he is placed, by a very adequate judge, among the most eminent observers and discoverers which the eighteenth century produced.[n] Another species of action of other bodies on the rays of light, producing what philosophers have called *inflection* and *deflection*, was suggested by our illustrious countryman Dr. RITTENHOUSE,[o] but was first demonstrated by the ingenious experiments of Mr. BROUGHAM.[p] From these and other facts, it appears that light is operated upon by material substances; that it is subjected to the laws of attraction, and, of consequence, possesses *gravity*. In the same sphere of experiment and observation may be mentioned Dr. SMITH and Mr. MITCHEL, of Great-Britain, who made many valuable computations with respect to the intenseness, and the best mode of measuring this subtle fluid. The property which various bodies, both animal and vegetable, possess of imbibing and emitting light, has also been investigated with more success by modern philosophers than during any former period. To which may be added, that a multitude of facts of the most interesting kind, relating to the *effects* of light on animal, vegetable, and mineral substances, have been made known within a few years past; and the nature and principles of some of these effects ingeniously and satisfactorily explored.

n See PRIESTLEY's *History of Optics*, 4to. London, 1772; from which many of the facts related in this sketch are taken.

Those who have perused this work need not be informed, that it is a very interesting one; and that the labours of Dr. Priestley, in collecting so many historical facts relative to the science of Optics, together with his own experiments, hints, and inquiries on the subject, entitle him to an honourable station among those who have deserved well of this science in the eighteenth century.

o Transactions American Philosophical Society, vol. ii.

p Philosophical Transactions for 1796.

The theory and laws of *vision* have received very great elucidation during the last age. Bishop BERKELEY, in his *Essay toward a Theory of Vision*, published in 1709, solved many difficulties which had attended the subject, and threw much new light upon it. He distinguished more accurately than any who had gone before him, between the immediate objects of sight, and those of the other senses, which become early and insensibly associated with them. He first showed that *distance*, of itself, cannot be determined immediately by sight alone; but that we learn to judge of it by certain sensations and perceptions which are connected with it. He led the way, also, in pointing out the difference between that *extension* and *figure* which we discover by means of *vision*, and that which we perceive by *touch*. By means of these investigations and discoveries he enabled philosophers to account for many phenomena in optics, of which the most learned had before given very erroneous accounts, or acknowledged themselves unable to furnish any satisfactory solutions. About the same time some valuable experiments and instructive publications were made on the seat and principles of vision, by M. DE LA HIRE, M. LE CAT, M. BOUGUER, and several other French philosophers. To these succeeded the inquiries of HARRIS, PORTERFIELD, JURIN, SMITH, and still more recently of REID[q] and WELLS.[r] In particular, the very difficult question of *apparent magnitude* and *distance* has been treated with great ability by BERKELEY and HARRIS; the phenomena of single and double vision have been solved by several of the persons above mentioned; and many remarkable fallacies of

q *Inquiry into the Human Mind on the Principles of Common Sense*, &c.
r *An Essay upon Single Vision*, &c. 8vo. 1792.

vision explained by Mr. MELVILLE, M. BOUGUER, and others.

The principles and laws of *colours* have also been much better understood since the commencement of the eighteenth century than before. On this subject it seems now to be generally agreed that the immortal NEWTON fell into essential mistakes. His idea, that the colours of bodies depend on the *magnitude* of their elementary particles, has, it is believed, at present, few advocates. After him this subject was considered, though in a more practical way, and with reference to the art of *dyeing*, by several French philosophers, especially by DUFAY, HELLOT, and MACQUER, who conducted their inquiries with great ability, pains, and perseverance, at the national expense. More recently, Mr. DELAVAL, of Great Britain, refining on the conjectures of NEWTON, attempted to deduce the varieties of colour from the different *densities* and *inflammability* of bodies. This work was for some time popular, but appears lately to have given way, in the public opinion, to the more enlightened and correct philosophy delivered on this subject by M. BERTHOLLET, and Dr. BANCROFT, who found the whole doctrine of colours on *chemical* principles—supposing that particular bodies reflect, transmit, or absorb particular rays of light, in consequence of certain *affinities*, or *elective attractions*, existing between the differently coloured matters, and the different rays of light, reflected, transmitted, absorbed, or made latent.[s]

But the discoveries and improvements in the construction of *optical instruments*, which the last age produced, are still more brilliant and interest-

[s] See *Experimental Researches concerning the Philosophy of Permanent Colours*, by EDWARD BANCROFT, M. D. F. R. S. 1794.

ing than any hitherto mentioned. Much was done, during the period in question, in the improvement of *Telescopes*. The *Refracting Telescope* was first in use. In this instrument no signal advantages of construction seem to have been devised from the time of HUYGENS, till the middle of the eighteenth century. It was then that Mr. DOLLAND, a celebrated artist of Great-Britain, discovered a method of correcting the inconvenience and errors arising from the different refrangibility of the solar rays; a difficulty, which, since the time of NEWTON, had been generally considered as insurmountable. He ascertained that lenses of *crown* and of *flint* glass might be so prepared and adjusted as to correct the refractive, and of course the chromatic powers of each other. On this discovery he founded the construction of his celebrated *Achromatic Telescope*, which, doubtless, deserves to be ranked among the most valuable acquisitions of the age. Mr. DOLLAND pursued this improvement by increasing the number of glasses, with so much success, as to make the refracting instruments of his time superior to the reflecting of equal length. The principle which he discovered was explored still further, and the Telescope which he contrived carried to a higher degree of perfection soon afterwards, by Mr. ZEIHER, of Petersburgh, who ascertained, by experiments, that increasing the quantity of *lead* in the formation of lenses, augmented the power so much desired in this instrument. And, still more recently, additional discoveries have been made respecting it, and additional means of correcting its inaccuracies devised, by Mr. ROBERT BLAIR, Professor of Astronomy in the University of Edinburgh.[t] It ought, perhaps, to be mentioned, that

[t] See Transactions of the Royal Society of Edinburgh, vol. iii.

the hints and publications of the celebrated EULER on this subject, though found erroneous, probably contributed something to Mr. DOLLAND's discovery; and that the distinguished mathematicians, CLAIRAUT and D'ALEMBERT, about the same time, rendered themselves very conspicuous among the philosophers of Europe, by their ingenious calculations and suggestions, in aid of the achromatic instrument.

But, from the necessary imperfection, and the small limits to which the *dioptric* plan of magnifying distant objects is confined, the improvement of the *Reflecting Telescope* became, early in the century, an object of particular attention. This instrument, which had been invented, in the preceding century, by Mr. JAMES GREGORY, of Aberdeen, and which had been executed, on a different plan, by Sir ISAAC NEWTON, was greatly improved by Mr. HADLEY, who, in 1719, presented a very powerful Telescope of this kind to the Royal Society. In 1734 Mr. SHORT, an ingenious artist of Edinburgh, devised still further improvements in this instrument. These were chiefly effected by a new method which he discovered of grinding mirrors. But the secret art which enabled him to do this with so much success, is said to have died with him. After him, Mr. MUDGE, of London, by making *specula* of a composition of different metals, and by inventing a method of grinding them in the *parabolic curve*, which had been considered so difficult a problem by his predecessors, effected yet greater improvements. Mr. MUDGE was followed by his countryman, Mr. EDWARDS, who also laboured, with considerable success, on the same instrument. But it was reserved for the great Astronomer HERSCHEL, to furnish the world with reflecting telescopes of the

most wonderful magnifying power. The extraordinary length to which he has carried his improvements, and the astonishing discoveries which they have enabled him to make, are too recent, and too well known to make a detail of them necessary here.

During the period which we are considering, *microscopes* have been also carried to very high degrees of perfection. In 1702 Mr. WILSON invented one, of the single kind, which is still much in use. In 1710 Mr. ADAMS presented to the Royal Society, another, also single, but of much greater magnifying power. To which succeeded, soon afterwards, the ingenious device of Mr. GREY, of a temporary microscope, by means of a globule of water. In 1738 or 1739, Mr. LIEBERKUHN made two very important improvements in microscopes, by the invention of the *Solar Microscope*, and that for viewing *opaque objects*. These were followed by the *reflecting microscope* of Dr. SMITH, said to be superior to all others. Besides those above mentioned, discoveries and improvements relative to microscopes, too numerous to be recounted, have been made by philosophers and practical opticians. The most conspicuous of these are CULPEPER, BAKER, ELLIS, LYONET, MARTIN, CUFF, ADAMS, and WITHERING; who have either contrived microscopes suitable for particular purposes, or suggested inventions and additions of more general application.

There is probably no division of this review, under which another modern invention, the *Telegraph*, may with more propriety be placed than this. Though something like *Telegraphic* communications had been attempted many centuries before, on particular military or civil emergences; yet nothing of this kind was reduced to regular

system, or much known, till the beginning of the eighteenth century,[v] when M. Amontons, of France, exhibited a telegraph on a new and convenient plan. It was not, however, until after the commencement of the French Revolution that this machine was generally applied to useful purposes, or became an object of much attention. Toward the end of the year 1793 M. Chappe announced an invention under this name. Whether he was acquainted with the contrivance of M. Amontons is not known; but be this as it may, his was nearly on the same plan. The invention of M. Chappe immediately became an object of public attention. Additions and alterations in his plan were proposed, and some of them highly advantageous; and telegraphs of different kinds came into use in various parts of the continent of Europe, and in Great-Britain. How great the importance of this channel of intelligence is at present, and how much more so it may be rendered by those improvements in its construction and management which we may reasonably expect to take place, will readily occur to every mind. To say nothing of the dispatch with which information may be conveyed, by this means, in time of war, and thus prevent much evil of various kinds, it may hereafter become an instrument of commercial communication of the highest utility, and may be rendered subservient to many valuable national purposes.[u]

The late experiments and conclusions of Dr. Herschel, with respect to the rays of light and

v It is said by a writer in the *Philosophical Magazine* of London, that the celebrated Robert Hooke, the contemporary and friend of Boyle, invented a *Telegraph*, on the same general plan of those which have been since used; and formally announced and described it, in a paper read before the Royal Society, May 21st, 1684.

u See Encyclopædia, art. *Telegraph*, and a paper on the same subject, in vol. i. of the Monthly Magazine of London.

heat, are curious, and highly interesting. He seems to have demonstrated that the different prismatic colours have different grades of temperature; that radiant heat, as well as light, is not only refrangible, but also subject to the laws of dispersion, arising from its different refrangibility; that those rays of light which have the greatest *illuminating* power are the *yellow*, and those which have the greatest *heating* power the *red*; and, of course, that, contrary to the general belief, the maximum of *illumination*, and the maximum of *heat*, do not coincide.[w]

ASTRONOMY.

Though this subject is mentioned last, it holds a very conspicuous place among those branches of mechanical philosophy which have received great accessions of discovery and improvement during the century in question. At the beginning of this period the *Principia* of the immortal NEWTON had given a new face to astronomical science. Much had been done by his predecessors, and especially by the sagacious KEPLER, to prepare the way for his grand discoveries; but it was reserved for this luminary of the first magnitude to shed a degree of light on the laws of our planetary system, which has served to guide every exertion, and point out the way to all progress which has since been made. It was he who first applied the simple principle of gravitation to account for the movements of the celestial bodies; who laid down the laws of this great and all pervading attraction; and thence, by the assistance of a sublime geometry, deduced the revolutions of the planetary orbs, both primary and

w See Transactions of the Royal Society for 1800.

secondary, including the minute irregularities of each, with some errors indeed, but with a degree of conformity to nature and subsequent observation, which must ever astonish and delight the inquiring mind. The British philosopher leaving astronomy in this improved state, no wonder that those who came after him should at once, with growing ardour, and with greater ease, pursue a course which he had so happily marked out.

At the beginning of the century under review, we find FLAMSTEAD, the first Astronomer Royal of England, devoting himself to this science with great zeal and success. He particularly directed his attention to the *fixed stars*; and after a series of patient and most laborious observations, published, in 1719, a catalogue of stars, more extensive and accurate than had ever been formed by one man. To him, both in office, and in astronomical fame, succeeded Dr. HALLEY, who made a number of important discoveries, and useful publications. Among many others which might be mentioned, he discovered the *Acceleration of the Moon*, and gave a very ingenious method of finding her *parallax*. He composed tables of the Sun, the Moon, and all the planets. He also recommended the mode of ascertaining the *Longitude* by *Lunar Observations*; a mode which has been since much improved, and generally adopted; and which is, at present, the most certain guide of the mariner. After him, at the head of the Royal Observatory was placed Dr. BRADLEY, who greatly distinguished himself as a practical astronomer. He was the first who made observations with sufficient accuracy to detect the smaller inequalities, in the motions of the planets and fixed stars. By means of this accuracy, he discovered, in 1727, the *aberration of the stars*, a phenomenon produced by the compound motion of the earth, and

the rays of light; and furnishing new proof, both of the materiality and amazing velocity of light, and also of the reality of that motion which had been ascribed to the earth. The same gentleman, in 1737, discovered the *nutation of the earth's axis*—that libratory motion, which is occasioned by the inclination of the moon's orbit to the ecliptic, and the retrograde revolution of her nodes; thus, in the course of ten years, making two of the most important additions to astronomical knowledge that the century produced.

While these noble and successful exertions were making in Great-Britain, to improve the science of astronomy, the philosophers of France were employing themselves in the same field of inquiry, and with very honourable success. The real figure of the globe we inhabit had not been, before this time, satisfactorily ascertained. M. CASSINI, the Astronomer Royal at Paris, believed its figure to be that of a *prolate spheroid*, or, in other words, that the *polar diameter* was greater than the *equatorial;* while NEWTON had been led, by his principles, to a conclusion directly opposite, and had taught that it must be an *oblate spheroid*, or flatted at the poles. To determine the question, between these contending powers, the French Royal Academy of Sciences, under the authority and patronage of LEWIS XV. resolved to have two degrees of the meridian measured, the one as near the Equator, and the other as near the Pole, as possible. For this purpose, one company of philosophers, consisting of Messrs. GODIN, CONDAMINE, and BOUGUER, to whom the King of Spain added Don ULLOA and Don JUAN, was dispatched, in 1735, to South-America; and another Company, consisting of Messrs. MAUPERTUIS, CLAIRAULT, CAMUS, LE MONIER, and OUTHIER, attended by Professor CELSIUS, of Upsal, were sent to Lapland.

These companies, after devoting several years to the task committed to them, and encountering numerous difficulties in the prosecution of it, at length completed their design. The result proved to be an ample confirmation of NEWTON's opinion; for a degree near the Pole being found to measure more than one near the Equator, they necessarily inferred that the polar degree must be part of a larger circle.[x]

At the beginning of the eighteenth century, our knowledge of the *Moon* was extremely defective. Since that period, so many discoveries have been made respecting this attendant on our earth, and the laws of her motion have been so ably and diligently investigated, that this part of astronomy may now be ranked among those which are most fully known and understood. For these investigations we are indebted to CLAIRAULT, D'ALEMBERT, EULER, MAYER, SIMPSON, WALMSLY, BURG, BOUVARD, DE LA GRANGE, DE LA PLACE, and others. By the labours of these great astronomers, the inequalities in the moon's motion have been detected, ascertained, and reduced to a system; accurate *Lunar Tables* have been formed; and the theory of this satellite has been carried to such a degree of perfection, that her place in the heavens may be computed with a degree of precision, which would have been pronounced, a few years ago, altogether impossible. With respect to the condition and aspect of the moon's *surface*, many important discoveries have been made, and much valuable information given to the world, by M. SCHROETER,[y] a celebrated astronomer of Goet-

x It is impossible to recollect the attempt by M. BERNARDIN DE ST. PIERRE, in his *Studies of Nature*, to revive the opinion of CASSINI on this subject without surprize. That so learned and ingenious a man should oppose such distinct mathematical demonstration, is one of those caprices of respectable minds not easy to be accounted for.

y See *Selenotopographische Fragmente*, &c. by JOHAN. HYERONYMUS SCHROETER, 4to. 1791.

tingen, and by Dr. HERSCHEL, of Great-Britain; who, by the aid of very powerful and accurate instruments, and with the skill and perseverance for which they are so eminently distinguished, have made surprizing progress in investigating this department of the lunar phenomena.

When NEWTON died, several of the *inequalities* of the planetary motions, arising from the disturbing forces of various bodies, were with difficulty reconciled with the astronomical principles which he had laid down. These inequalities have been successively investigated since that time, their causes ascertained, their laws fixed, their perfect consistency with the Newtonian theory demonstrated, and thus a very formidable objection to that theory satisfactorily removed.—It is known to mathematicians, that this celebrated philosopher, calculating the effect of the sun's force, in producing the *precession of the equinoxes*, fell into an error, and made it less, by one half, than the truth. The true quantity of this motion was first determined by M. D'ALEMBERT, in 1749; who also, in the course of his inquiries, more fully explained the *nutation of the earth's axis*, which had been discovered a few years before by Dr. BRADLEY. With no less diligence the inequalities in the revolutions of all the planets, and especially of *Jupiter* and *Saturn*, have been examined, ascertained, and reduced to regular principles. In these difficult investigations, many astronomers have employed themselves, in the course of the last century, and by their labours rendered important services to this science; but, perhaps, none of the number deserve more honourable distinction than EULER, DE LA PLACE, and DE LA GRANGE, whose accurate observations, and rigid and delicate analyses, with a view to explore the anomalies in

question, display great penetration, diligence and perseverance.

The year 1781 was rendered remarkable by the discovery of *a new primary Planet.* This discovery was made by the celebrated HERSCHEL, an astronomer of Hanover, residing in Great-Britain. He had, for a number of years, distinguished himself by his successful exertions in augmenting the powers of optical instruments, and particularly in improving the reflecting telescope. With an instrument of this kind, of great excellence, he first determined the existence of the *Planet,* which he denominated *Georgium Sidus,* in honour of the British King; but which is now generally called, by the consent of astronomers, after his own name. From his observations, and those of others, it has been since found that this planet is attended by *six* secondaries, and much progress has been made in ascertaining the respective times and laws of their revolutions.[z]

But this discovery is not the only one which will transmit the name of Dr. HERSCHEL to posterity with distinguished honour. In 1787, he discovered a *sixth* satellite of *Saturn,* and the year after a *seventh,* attending the same planet. He ascertained the rotation of *Saturn's Ring,* which may be regarded as one of the most important additions made to astronomical science since those of Dr. BRADLEY. He discovered a *second ring* belonging to that planet, and actually observed fixed stars between this and the one before known. He discovered also around the same planet a *quintuple belt of spots,* by which he ascertained the re-

z On the first day of the nineteenth century (January 1, 1801) *another new primary Planet* was discovered by M. PIAZZI, of Palermo, in Sicily, which is likewise called by the name of the discoverer. It is not apparently larger than a fixed star of the eighth magnitude. The inclination of its orbit to the plane of the ecliptic is about 10 deg. 36 min. 57 sec. and its periodical revolution a little more than four years.

ality and the time of its diurnal motion. He has published new and valuable observations on the sun, the moon, and indeed on almost all the bodies belonging to the solar system. He has greatly enlarged our acquaintance with the fixed stars; and, in a word, so much extended our knowledge of astronomy, that his life may be considered as forming one of the most important æras in the history of this branch of philosophy.

At the close of the seventeenth century, the respective *distances* of the several planets from the sun were far from being accurately determined. These, by successive observations, have been since ascertained, with a great degree of precision; and the various astronomical uses which this knowledge is calculated to subserve, have been displayed in the most satisfactory manner. Particularly the observations made by many philosophers on the *transits* of *Venus* and *Mercury*, which the eighteenth century exhibited, have thrown much light on this subject, and on several questions of great importance in astronomy.

It is but a few years since our knowledge of *Comets* was in its infancy. Dr. HALLEY, at the beginning of the period under consideration, made the first attempt to give a systematic view of this part of the science in his *Synopsis Astronomiæ Cometicæ*, published in 1705. But his inquiries, concerning these excentric bodies, though ingenious and highly valuable, were far from being adequate or satisfactory. By the labours of modern astronomers, our acquaintance with the comets has been wonderfully extended. *Sixty eight* new ones have been observed; the return of many of them has been ascertained and demonstrated,[a] and many curious facts respecting them

[a] M. DE LA LANDE, in his *History of Astronomy*, for the year 1801, intimates, that the observations which took place in the course of that year

discovered, and received ample illustration. The learned and indefatigable labours of Father Boscovich, and of M. De la Place, for determining the orbits of comets, have been long known and praised by astronomers. The great works of M. Pingre, and of Sir Henry Englefield, on this branch of astronomical philosophy, are entitled to a place among the most full and useful of those which have appeared on the subject.[b] But besides what has been effected by the useful inquiries of these gentlemen, the observations of many others, and particularly of De Lalande, and his countrymen, Messier, and Mechain, and also of Burckhardt, an illustrious German astronomer, have contributed much to extend our knowledge of comets. It is further worthy of remark, that the difficulty of making observations on comets has been, within a few years, greatly diminished. The methods of calculating their elements are now short and easy, in comparison with what they were half a century ago. Operations which then occupied many days, may now be dispatched with accuracy, in a few hours.

The importance of accurate observations on the *fixed stars*, in order to ascertain their motion, places, and relative circumstances, is known to every astronomer. It is to the stars we are obliged to refer all the motions of the sun, the planets, and the comets. In this part of the science under consideration, much has been done during the last century. The catalogue of stars

have made it questionable whether the doctrine long entertained, and considered as settled by him and other astronomers, that comets revolve, be not erroneous. This doubt will probably soon receive a solution, if the spirit of zeal and industry should continue which at present animates many European philosophers.

b *Treatise on Comets*, by M. Pingre, 2 vols. 4to. Paris, 1783. *The Determination of the Orbits of Comets, according to the Methods of Father* Boscovich, and M. De la Place, *with new and complete Tables*, by Sir Henry Englefield, 4to. 1799.

formed by FLAMSTEAD, was before mentioned as one of the most complete ever derived from the labours of an individual. To this succeeded the observations and catalogues of DE LA CAILLE, BRADLEY, and MAYER, which it is scarcely necessary to say were highly valuable. After these, M. BODE, of Berlin, published, in 1782, a very extensive and improved catalogue, which is greatly esteemed among astronomers. He was followed by the celebrated Baron DE ZACH, of Gotha, whose catalogues and tables, in many respects, excelled all that had preceded them. Besides these, the public has been favoured with interesting accounts of new stars, by HERSCHEL, MASKELYNE, the elder LALANDE, and many others. The number discovered by the powerful instruments of HERSCHEL, in particular, is almost incredibly great. But the last, and the most complete series of observations ever made in this department of astronomy, is that lately announced by LE FRANCAIS LALANDE, the nephew of the veteran in science, of the same name before mentioned, who, with the assistance of his ingenious and enterprizing wife, has determined the places of fifty thousand stars, from the Pole to two or three degrees below the Tropic of Capricorn.[c]

We may also reckon among the great astronomical improvements of the last age, the formation of many *Tables*, exhibiting the places and motions of the heavenly bodies. Among these are the *Cometarial Tables* of Dr. HALLEY, since enlarged and corrected by many hands, and particularly by a number of eminent French astronomers. To the same list also belong *Tables* of the *Sun* and *Moon*, by LE MONIER, and DE LA HIRE; the *Solar Tables* of DE LA CAILLE, DAWES, DE LAMBRE, and DE

c See LALANDE's *History of Astronomy* for 1800.

ZACH; and the successively improved *Lunar Tables* of CLAIRAULT, EULER, MAYER, MASON, and finally, of BURCKHARDT, founded on the observations of BURG and BOUVARD. Tables of all the primary *Planets*, and their *Secondaries*, have been completed during the period in question; among the most valuable of which are those of BRADLEY, CASSINI, DE LAMBRE, WARGENTIN, VIDAL, ORIANI, SCHUBERT, BURCKHARDT, and DE LALANDE. Tables of *Parallax* and *Refraction* have been formed by BRADLEY, DUNTHORNE, and SHEPHERD, particularly the last, whose work is a wonderful monument of industry and perseverance. To these might be added a multitude of others, published by individuals, and learned societies, various sets of which may be found in modern books of astronomy. Those printed in DE LALANDE's great systematic work, are probably exceeded by none extant in fulness and accuracy. By means of these *Tables*, many complex calculations, which, without their aid, would cost the labour of several hours, or even days, may now be performed in an eighth or tenth part of the time which they formerly employed, and with much greater assurance of a true result.

Previous to the eighteenth century, though *Eclipses*, of various kinds, had been observed and calculated, yet these operations had rarely been made subservient to any important practical purpose. Within a few years past, philosophers have paid more attention to this part of astronomy. Methods have been devised of calculating eclipses with more ease and expedition than before. Large collections of these calculations have been made, for a long series of years, with the view of deducing from thence the longitude of cities, and determining other astronomical and geographical questions. Among those who have distinguished

themselves in this branch of astronomy, M. TRIESNECKER, of Germany, and M. GOUDIN, of France, are entitled to peculiar honour.[d]

To discover an easy and certain method of finding the *Longitude*, has long been a grand *desideratum* among astronomers and navigators. In 1714, an association was formed in Great-Britain, under the denomination of the *Board of Longitude*, aided by the authority and patronage of the government. The exertions and the liberality of this body have done honour to their age and country, and in a very pleasing degree, attained their important object. The most approved mode of ascertaining the Longitude now in use, viz. by observing the distance of the *moon* from the sun, or from certain stars, though repeatedly suggested, was never reduced to practice till the eighteenth century. In promoting this object Dr. HALLEY early distinguished himself. To him succeeded several others, who formed *Lunar Tables*, with a view to facilitate the necessary calculations; but among these, none laboured with so much success as Professor MAYER, of Gottingen, whose tables

d The attempts made by certain infidels, during the eighteenth century, to derive an argument against the chronology of the sacred writings, from some astronomical records, said to be found in Asia, is well known; as are also the ample refutation of their reasoning, and the total disappointment of their hopes, from this quarter. We have been recently informed, that some of the learned men of France, connected with the late military expedition to *Egypt*, assert, that in the course of their inquiries in that country, they discovered astronomical records, which prove the age of the world to be many thousands of years greater than the sacred history represents it. It is not the part of a wise man to *answer a matter before he heareth it*, and therefore until more shall be known concerning the facts stated, and the reasonings employed by these men, it would be improper to attempt a discussion of the subject. But the extreme fallacy to which arguments derived from sources of this kind are liable, must be obvious to every astronomer; and he must have little acquaintance with the history of human knowledge who does not know, that assertions as bold as those in question have more than once been demonstrated to be false; that expectations as sanguine have been often blasted; and that modern discoveries in science, and the observations of travellers, instead of discrediting the sacred history, have uniformly tended to illustrate and confirm it.

were brought to such a degree of accuracy as to be thought worthy of a large premium from the Board of Longitude, before mentioned. Mayer's tables were afterwards improved by Mr. Charles Mason, of England, who reached a still greater degree of precision in his calculations. And finally, to the Rev. Dr. Maskelyne, the present Astronomer Royal of Britain, is due the honour of contributing much toward the perfection of the plan, and of introducing it into general practice.

Another method of finding the Longitude, by observations on the *Eclipses of Jupiter's moons*, though practised as early as 1688, has yet been much improved during the period under discussion. For these improvements, which are chiefly founded on the superior extent and accuracy of modern tables, we are indebted principally to Drs. Bradley and Pound, M. Cassini, the younger, Mr. Wargentin, and M. Delambre, of whom the tables of the last have been generally adopted in many of the late nautical almanacks. A third mode of determining the Longitude, by well regulated *Time-keepers*, is almost wholly a production of the last age. For although some attempts of the kind were made in the preceding century, nothing effectual was done until 1714, when Henry Sully, an Englishman, published a small tract at Vienna, on the subject of watch-making, and announced some improvements in the art, with a view to the Longitude, which were said to be valuable, and attended with success. This plan, however, was afterwards brought much nearer to perfection, by the ingenious and persevering labours of John Harrison, also of England, who, in 1726, produced a time-keeper of such uncommon accuracy as not to err above one second in a month, for ten years together. Watches of a similar kind, and which have proved of great uti-

lity to navigators, were also formed soon after Harrison's, by KENDAL, ARNOLD, and others of Great-Britain, and by several distinguished French artists. The happy effects of these discoveries and improvements in aiding navigation, and, of course, their favourable influence on commerce and the interests of humanity, are so obvious as not to require formal explanation.

But no age, assuredly, can vie with the last, in the accuracy and astonishing powers of the *astronomical Instruments* which it produced. The principal ones, among those of an *optical* kind, were mentioned in a former part of this chapter, and need not be again recounted. In addition to these, many curious instruments and *machines*, serving to illustrate and exemplify the principles of astronomy, have been devised by ingenious men. The first deserving of notice is the *Orrery*, invented by Mr. GEORGE GRAHAM, an English mathematical-instrument-maker, and presented to GEORGE I.[e] The next is a machine, under the same name, contrived by Mr. JAMES FERGUSON, also of England, and including some improvements on the former. To these succeeded a *Planetarium*, of very curious structure, by Mr. WILLIAM JONES, of London, and the celebrated astronomical *Sphere*, by Dr. LONG, Professor in the University of Cambridge; to say nothing of a multitude of other inventions of a similar kind, by different artists and astronomers. But among all the contrivances of this nature which have been executed by modern talents, the machine invented

[e] The origin of the name given to this machine is as follows. Mr. ROWLEY, a mathematical-instrument-maker, having obtained one from GRAHAM, the inventor, to be sent abroad, with some of his own instruments, he copied it, and made one for the *Earl of* ORRERY. Sir RICHARD STEELE, who knew nothing of Mr. Graham's right to the invention, thinking to compliment the noble encourager, called it an *Orrery*, and gave ROWLEY the praise due to GRAHAM.

by our illustrious countryman, Dr. DAVID RITTENHOUSE, and modestly called by him an *Orrery*, after the production of Graham, is by far the most curious and valuable, whether we consider its beautiful and ingenious structure, or the extent and accuracy with which it displays the celestial phenomena.[f]

Among the instruments for making astronomical observations, invented during the last century, there is none more important than the celebrated *Quadrant*, invented by Mr. GODFREY, of Philadelphia, though afterwards claimed as a production of Mr. HADLEY, whose name it still bears. The inestimable value of this instrument, for various purposes, and especially for the direction of the mariner, is well known. Since the original plan of constructing it was announced, improvements of much value have been suggested by the Rev. Dr. EWING,[g] Provost of the University of Pennsylvania, by Professor PATTERSON,[h] of the same institution, and by Mr. MAGELLAN, of London. We may next mention the *Astronomical* or *Equatorial Sector*, an instrument of great utility, invented by the ingenious Mr. GRAHAM, before mentioned; the *Transit and Equal Altitude Instrument*, first made for LE MONNIER, the French astronomer, by Mr. SISSON, of London; and the *Grand Astronomical Circle*, by BORDA and others, the most complete and comprehensive instrument in use among astronomers, being in fact a kind of portable observatory, and probably carrying the

f For a further account of this celebrated *Orrery*, see the *Transactions of the American Philosophical Society*, vol. i. Those who wish to see a brief and comprehensive view of the genius, character and works of Dr. RITTENHOUSE, will find a good sketch of them in an *Eulogium*, pronounced in honour of his memory, before the American Philosophical Society, by Dr. RUSH.

g Transactions of the American Philosophical Society, vol. i.

h *Ibid.* vol. iv.

delicate accuracy of its indications to nearly as great a length as human art will admit. Nor ought it to be omitted here, that the method of *graduating* astronomical instruments has, within the last age, received the most astonishing improvements. Mr. BIRD, of Great-Britain, was long distinguished in this line; but more recently his countryman, Mr. RAMSDEN, has invented a method incomparably more easy, expeditious, and accurate than any before known. The abridgement of labour by this new method is scarcely credible. An operation which cost Mr. BIRD several days, we are told, can now be performed much better upon Mr. RAMSDEN's plan, and nearly in as many minutes.

Besides the invention of new astronomical instruments, the last age is also remarkable for the great improvement of almost all which were before known and in use. The services, by these means, rendered to astronomy by the artists mentioned in the last paragraph, and also, by SHORT, GRAHAM, HERSCHEL, TROUGHTON, and others, among whom might be mentioned several French artists of eminence, are too numerous and important to be adequately acknowledged in this place. These improvements have, no doubt, served greatly to abridge the labour of astronomical calculations, and to confer new accuracy upon every part of the science.

At the conclusion of the seventeenth century, the number of regularly established and endowed public *Observatories* was small. It is believed that only *two*, or at most *three*, of any distinction existed on earth. Within the last century, the number of these institutions has greatly increased. They are now established in almost every part of Europe; richly furnished with the best apparatus for making observations; and continually sending

forth discoveries and improvements, as the best evidence of their utility.

But astronomy has not only been enriched by the augmentation of its own immediate revenues; it has been also improved, during the period in question, by the collateral aid of other sciences and arts. The improvements in the *mechanic arts*, by furnishing the astronomer with more perfect instruments, have materially furthered him in his course. The discoveries in *dynamics* and *optics*, and the refinements which have taken place in *mathematical* science, though apparently of small moment when considered in themselves, yet, when applied to astronomical investigations, have proved highly important and useful. Formerly astronomy could only be improved through the medium of actual observation; but when the great Newtonian theory of the solar system was once established, a new path of inquiry, and new grounds of calculation, were laid down. *Data*, from that period, were afforded for ascertaining, with great precision, the orbits, the revolutions, and the inequalities of the several planetary bodies; and new light and aid poured in on every side, from the geometrician and the artist, as well as from the immediate inquirer in this sublime science.

Under this head it is proper to mention the introduction of the *New* or *Gregorian Style* of chronology into Great-Britain in 1752. In 1582 Pope GREGORY XIII. finding perplexity to arise in the computation of time, from some errors in the *Julian Kalendar*, which, antecedently to that period, had been used throughout Christendom, thought proper to order the formation and adoption of a new style of reckoning. The astronomers and mathematicians whom he summoned to Rome for that purpose, after spending several years in investigating the subject, and adjusting the prin-

ciples of another system, produced what has been since called the *Gregorian Kalendar*. In forming this method of computation eleven days were anticipated or lopped off from the old Kalendar, and a plan attempted for maintaining more chronological accuracy, by a proper distribution of *Epacts* through the year. The *Gregorian Style*, thus formed, was soon adopted by all the Catholic states, and in most of the Protestant countries, before the commencement of the eighteenth century. In Britain, however, and her dependencies, and in a few other Protestant states, the *Julian* or *Old Style* was not given up for a number of years afterwards. In 1752, by an act of the British Parliament, the *Gregorian Kalendar* was adopted, and, at the same time, the *Ecclesiastical Year*, which had before commenced on the 25th of March, was made to coincide with the *Civil Year*, and ordered, like that, to be computed from the first of January.

Besides the great names, and the important discoveries and improvements above detailed, it could be easy to add to the list many more abundantly worthy of notice. The numerous observations and writings of FERGUSON, LAX, VINCE, and others of Great-Britain; of BAILLY, DE PARCEVAL, BERNIER, SEJOUR, and DUVAUCEL, of France; of LAMBERT, GRISCHOW, OLBERS, DE WAHL, WURM, and KLUGEL, of Germany; of BIANCHINI, FRISI, MANFREDI, ZANOTTI, ODDI, CAGNOLI, and ORIANI, in Italy; of KLINGENSTIERNA, MALLET, PROSPERIN, and MELANDERHIELM, in Sweden; of RŒMER, LOOWENOERN, BUGGE, and WURBIERG, in Denmark; and of many others, in almost every part of Europe, have all contributed something to the astronomical improvements of the age, and facilitated the acquisition of astronomical knowledge.

Nor has *America* been destitute of zealous students, and successful observers in astronomy. Besides the illustrious RITTENHOUSE, before mentioned, whose name alone would rescue his country from the charge of deficiency in astronomical genius, we can boast of COLDEN,[i] WINTHROP, EWING, BOWDOIN, MADISON, PAGE, PATTERSON, ELLICOTT, WILLARD, and several others,[j] who, if they have not made splendid discoveries, nor great additions to astronomical science, have yet published useful observations, and contributed to promote that degree of taste for this branch of philosophy which exists in our country.

From the foregoing review, it will appear, that almost every part of mechanical philosophy, during the eighteenth century, has undergone great and radical improvements; and that the path is evidently marked out to still greater and more interesting attainments. For much of this progress we are indebted to accident; but our obligations are also great to the genius and industry of individuals, and the labours and publications of many learned societies, who have with honourable zeal and perseverance encouraged experiments and enterprizes of discovery; and collected and made

i See *Principles of Action in Matter, and the motion of the Planets explained from those Principles*, &c. by CADWALLADER COLDEN, Esq. 4to. London, Dodsley, 1753. And also a subsequent publication by the same author, in the form of a *Letter to the Earl of* MACCLESFIELD, explaining the doctrines contained in the former work. Mr. COLDEN was for some years prior to the American Revolution Lieutenant-Governor of the province of New-York. Whatever may be thought of some of the opinions exhibited in these publications, they display genius, learning, and an unusual taste for mathematical and astronomical inquiries.

j The specimens which have been given to the public of the astronomical learning and skill of most of the gentlemen mentioned above, and of some other Americans, may be found in the volumes of *Transactions* which have been published by the *American Philosophical Society*, and in the *Memoirs of the American Academy of Arts and Sciences.*

known a multitude of important facts. It is also a remarkable characteristic of the age, that every branch of natural philosophy has been investigated in modern times, in a more *practical* manner than ever before, and more extensively and generally applied to purposes of *economy* and the *arts*. While the explorers of science have gratified liberal curiosity, and gained reputation for themselves, their inquiries have been rendered subservient to the abridgment of labour; the increase both of expedition and elegance of workmanship, in manufactures; and the promotion of human comfort, to a degree beyond all former precedent. In short, the number of heads and of hands at work, in the various departments of mechanical philosophy, at the close of the century under consideration, was unquestionably much greater than ever before since science was an object of human study. That much further, and more satisfactory light, therefore, may be expected to break in upon us, at no great distance of time, on many points at present involved in darkness, can hardly be doubted. "But the subject," says an eloquent writer, "is "still greater than our exertions, and must for ever "mock the efforts of the human race to exhaust "it. Well did Lord BACON compare natural phi-"losophy to a pyramid; its basis is indeed the his-"tory of nature, of which we know a little, and "conjecture much; but its top is, without doubt, "hid high among the clouds. It is *the work which* "*God worketh from the beginning to the end*, in-"finite and inscrutable!"[k]

[k] Bishop WATSON's *Chemical Essays*, vol. i. p. 15.

CHAPTER II.

CHEMICAL PHILOSOPHY.

AS Mechanical Philosophy has a respect to those motions of the larger bodies of the universe which fall under the inspection of our senses, so Chemical Philosophy is the science which explains those motions which take place among the minute component parts of bodies, and which are known chiefly by the effects which they produce; in other words, its object is, "to ascertain the ingredients "that enter into the composition of bodies—to examine the nature of these ingredients, the manner "in which, and the laws by which, they combine, "and the properties resulting from their combination." It may safely be asserted, that there is no branch of science in which the discoveries and improvements, during the last century, have been more numerous, or more important, than in this. Indeed, such has been their number, and their interesting nature, that to exhibit them in detail would be to fill many volumes.

Though some of the facts and principles which enter into all the systems of modern chemistry have been known for many centuries, and indeed as far back as history reaches; yet, as a regular science, it could scarcely be said to have had an existence prior to the middle of the seventeenth century. It was about that time that the learned societies in Europe began to be formed, and the reign of Alchemy to decline. In the inquiries then instituted in chemical philosophy, the celebrated Mr. BOYLE led the way. His speculations and experiments

on light, heat, air, water, and other subjects allied to those, were in several respects useful, and prepared the way for subsequent improvements. To his learned labours succeeded those of Dr. MAYOW, who not only prosecuted the inquiries commenced by BOYLE, but had also the honour of devising others, equally new and important. He went far in discovering some of the properties of that portion of the atmosphere which has been since called *vital air* and *oxygen*, and ascertained the necessity of its presence for the purposes of combustion and respiration.[l] The discoveries and the works of this experimental philosopher, however, notwithstanding their curious and valuable nature, strangely fell into forgetfulness, and a century after their publication were scarcely at all known among the learned of Europe. In the list of luminaries in chemical science, the immortal NEWTON next appears. Though his mind was chiefly occupied in exploring other regions of philosophy, he was by no means regardless of this; and about the beginning of the eighteenth century he first suggested the idea of arranging the phenomena of chemistry under the head of a peculiar species of attraction. The chemists who lived before this great philosopher supposed that all solvents, or substances capable of dissolving others, were composed of particles which had the form of wedges or hooks; that solution consisted in the insinuation of these wedges or hooks, between the particles of the bodies to be dissolved; and that chemical combination was merely the linking of the different particles together, by means of holes in one set of them, into which the hooks or the wedges of the other set were thrust. Such explanations, absurd as they may appear, were generally fashiona-

[l] *Tractatus Quinque Medico-Physici*, p. 12 and 106.

ble, until NEWTON first ascribed the chemical union of bodies to an *attraction* between the particles themselves—a doctrine which was soon unanimously received, and has continued ever since to prevail. The nature and laws of this attraction were afterwards better explained and systematized by Mr. GEOFFROY, a philosopher of France, who invented a method of representing the different chemical affinities by figures and diagrams, and arranging them in tables; a method which has been since generally received into practice, and which has greatly contributed to the facility and advancement of this science. Contemporary with GEOFFROY was BOERHAAVE, who, among the various objects to which he directed his great and excellent mind, made himself conspicuous by his attention to chemistry. He made many new experiments, and improved almost every part of chemical philosophy which was then known. He was particularly distinguished by maintaining, in opposition to BOYLE and NEWTON, that *heat* was a real specific *substance*, a fluid universally diffused, and one of the most important agents in nature. In supporting this doctrine he triumphed over his illustrious opponents, and established a principle which has been in substance generally adopted by the philosophical world since that time.

At an early period of the eighteenth century STAHL, an eminent German chemist, published his theory of *Phlogiston*, which produced one of the most remarkable revolutions in chemical philosophy that ever occurred. This theory had been invented and published, in the preceding century, by BECHER, a philosopher of Germany; but he died before it obtained that character and currency which it afterwards acquired. It was reserved for STAHL to adopt and systematize his doctrines in a manner so plausible and consistent

as to secure for them a general reception. According to this celebrated theorist there is only one substance in nature capable of combustion, which, therefore, he called *phlogiston;* and all those bodies which can be made to burn contain more or less of it. Combustion is merely the separation of this substance, which, during the process, flies off, leaving the incombustible body with which it was connected behind. He supposed the conversion of sulphur into an acid, by the action of heat, most completely to illustrate and confirm his doctrine; and, indeed, so ingeniously devised, and so extremely plausible were his experiments on this subject, that he was considered as having satisfactorily established, both in the *analytic* and *synthetic* methods, the principle for which he contended. Objections, it is true, were made to this theory, for it was soon found that sulphur would not burn, if air were completely excluded, and that the sulphuric acid was heavier than the supposed compound from which it was produced. But still the *phlogistic* doctrine prevailed. The simple, luminous, and satisfactory manner in which it appeared to account for various phenomena, and the numerous facts which seemed to give it support, aided by the ingenious refinements of its partizans, for a considerable time, bore down all opposition.

The theory of Stahl maintained its ground for more than half a century. It commanded the general assent of chemical philosophers, and was especially adopted and defended by some of the most eminent men which the age produced. And although it is now rejected by a great majority of those who cultivate the science of chemistry; yet neither the ingenuity of the system, nor the talents of its author, can, for a moment, be questioned. Indeed, the doctrine of this great man, though at

present generally considered as erroneous, was by no means an useless effort of mind. Before the publication of his theory, the different branches of this science had been studied in a manner too detached and unsystematic; experiments had been made with too little accuracy; and scarcely any luminous and generalizing views had yet been given of the subject. In the fair and ingenious fabric of Stahl, the scattered fragments produced by preceding inquirers were arranged and combined; experiments began to be conducted with a spirit of more acute and precise observation; and the whole aspect of this department of philosophy became more regular and scientific.

Assuming his theory, as in general the only true one, and proceeding on its fundamental principles, the philosophers who followed him devised considerable improvements, and made many important discoveries. The Rev. Dr. Hales revived the pursuit of *pneumatic* chemistry, which had been generally neglected since the time of Mayow; and, indeed, the honour of being the father of this branch of the science belongs more eminently to him than to any other individual. He found that many substances were readily convertible from the fixed to the gaseous state, and *vice versa;* he carried his inquiries into the effects of fermentation, dissolution, combination, combustion and respiration, further than any who had gone before him; he made great improvements in the necessary machinery and apparatus for pneumatic experiments; and, on the whole, was the author of many valuable additions to the science. Soon afterwards Dr. Black published the celebrated doctrine of *latent heat*—a doctrine of fundamental importance, and of great extent in its relations. He also ascertained the existence and some of the properties of *fixed air*, since called *carbonic acid gas*—a substance

which holds a high place in modern systems of chemistry. Some other distinguishing properties of this air, and the relations which it sustains to various bodies, were further investigated by Dr. RUTHERFORD, Professor MACBRIDE, Mr. LANE, and others.

Immediately succeeding to these brilliant discoveries, were those of Mr. HENRY CAVENDISH, who, in 1766, with more success than any preceding inquirer, examined the nature, and ascertained the properties of *inflammable* (or *hydrogen) air;* and a few years afterwards made the grand discovery of the *composition of water*, which was destined soon to become the corner-stone of a new theory. In the mean time, Sir TORBERN BERGMAN, an illustrious Swede, was busily engaged in exploring the same department of philosophy. In the course of his inquiries, he threw great light on the subject of *elective attractions;* enlarged and explained more satisfactorily the tables of *affinities;* gave much new and valuable information, relating to the constitution of *volcanic* and other mineral substances; made a considerable reform in the nomenclature of the science, and accomplished so large an amount of improvement, that he may be justly styled one of the great fathers of chemistry. Contemporary with BERGMAN was his celebrated countryman SCHEELE, one of the most extraordinary men and distinguished philosophers of the age in which he lived. He has been justly called the *Newton* of chemistry. Without the aid of education or of wealth, his genius burst forth, and shone with astonishing lustre; insomuch that at the age of forty-four, when he died—an age at which most other great men have but begun to attract public attention—he had finished a career of discoveries which have no equal in the annals of chemistry. He made new and ingenious *analyses* of

many bodies, the composition of which had never before been accurately investigated. He discovered vital or *oxygenous* air, about the same time with Dr. PRIESTLEY, and without any knowledge of what had been done by that celebrated philosopher. He discovered a number of new *acids*, and exceedingly enlarged the lists of chemical substances. He made known a number of new *paints* and *dyes*, and in various ways contributed to the progress of arts and manufactures. In short, he instituted such a variety of original and interesting experiments, and threw so much light on almost every branch of chemical science, that a volume might be filled with their history, and with the praises of his ingenuity, diligence, enterprize and success.

Next, in this honourable catalogue, stands Dr. PRIESTLEY, whose fame as the author of numberless valuable experiments, and many important discoveries, is known in every part of the world where philosophy is cultivated. His labours, particularly in pneumatic chemistry, have been extensive, various and persevering to a wonderful degree. Among many other services rendered to this branch of science, he discovered the *nitrous* and *oxygenous* airs; he first exhibited acids and alkalies in the *gaseous* form; he discovered the power of vegetation to restore vitiated air; he ascertained the influence of light in enabling vegetables to yield pure air; and he threw much light on the principles of respiration, and the influence of oxygenous air on the blood. But the great extent and value of his inquiries, respecting the analysis of the atmosphere, and the production of various factitious airs, can be fully understood only by the perusal of his instructive volumes on these subjects.

To the list of successive luminaries in chemistry, now under review, it would be improper not to

add the name of M. Macquer, who contributed, in an eminent degree, to the advancement of chemical knowledge, by his excellent works, long held in the highest esteem, in every part of Europe. His ingenious experiments and numerous discoveries, particularly respecting *arsenic*, *dyes* and *earths*, will ever entitle him to honour and gratitude from philosophers. By the labours of these great men, and of many others, whose names might with propriety be mentioned, did not our limits forbid such an enlargement of the list, the boundaries of chemical philosophy had been more extended, and its stores of experiment and discovery more enriched, within the twenty years immediately preceding the introduction of the theory of the French Academicians, than in any whole century before.

All the great chemists whose names have been mentioned, were, at this time, votaries of the *phlogistic* theory of Stahl. Their experiments and discoveries, indeed, were sometimes found to militate strongly against this popular doctrine, and some of them ventured occasionally to call in question its leading principles. Still, however, discerning no preferable ground on which to rest, and finding some ingenious devices to reconcile discordant appearances, they adhered, in general, to the opinions of the illustrious German. But the fair structure of this great philosopher was doomed, like most human labours, to be soon overturned by the restless hand of innovation. The experiments on *metals*; the discovery of various facts and principles with respect to the matter of *heat*; and especially the discovery of the *composition of water*, began to produce a conviction in the minds of some leading chemists in France, that the doctrine of *phlogiston* was utterly insufficient to account for the phenomena which they witnessed. Macquer and Bayen seem to have been among the first who

declared their dissatisfaction with STAHL's theory. Their objections were adopted by a number of contemporary inquirers; but they contented themselves with an ingenious modification of the system, instead of an entire abandonment of it. To these objections succeeded a number of papers, in the *Annales de Chemie*, and the *Journal de Physique*, by LAVOISIER and others, which indicated a growing dissatisfaction with the popular opinions, gradually introduced new modes of reasoning, and promised the approach of a grand epoch in the history of this science.

But it was not only the *doctrines* of chemistry that called for reform. Complaints had been long made that the *nomenclature* of the science was inaccurate, perplexed and inadequate.[m] To remove these complaints many attempts had been made by chemical philosophers. It has been already observed that BERGMAN laboured much to forward this branch of improvement. SCHEELE contributed to the correction of several old names, and added many new ones to the list; and MACQUER discarded a number of the ancient terms, and substituted others less exceptionable in their place. Still, however, the evil, notwithstanding these partial reforms, continued and increased, until it became a serious impediment in the course of the student. Hitherto the number of objects which had engaged the attention of chemists, had been comparatively small. The *acids* amounted only to *five*; the *earths* to *four*; the *metals* to *twelve* or *fourteen*; and the *neu-*

m Some of the most familiar preparations were distinguished, by the old chemists, by the most ridiculous and unmeaning names. They loaded their nomenclature with such jargon as the following: *Liver of sulphur—mercury of life—butter of antimony—horned moon—the double secret—the corraline secret—the salt of many virtues—the foliated earth of tartar*, &c. To these, some still more capricious and inconvenient might be added. The difficulties and the mischief of retaining such a language must be apparent to every chemist.

tral salts hardly exceeded *twenty*. To remember the names of so small a number of bodies, however inaccurate, or injudiciously selected, was no difficult task. But when the discoveries of HALES, BLACK and CAVENDISH had laid the foundation of pneumatic chemistry, the boundaries of the science began to enlarge with inconceivable rapidity, and the number of objects became, in themselves, and in their combinations, little short of immense. To have borne the names of all these objects in the memory, without any catenation between them, upon philosophic principles, without establishing a system of mutual dependance and relation, more simple and intelligible than had hitherto been done, would have been a task beyond ordinary powers. Such was the state of things, when a variety of concurring circumstances led to another and a greater revolution than had before occurred.

As early as 1782 M. DE MORVEAU proposed a *general* reform in the language of chemistry. At that time he had undertaken the management of the chemical part of the *Encyclopædie Methodique*.[n] Before entering on the execution of this great task, he thought it proper to lay the outlines of his plan before the most eminent chemists of France, that his labours, when completed, might have the stamp and authority of a national system. To this end, he published a memoir, after reducing to a regular form the various doctrines which had been, for a number of years, maturing in the minds of several of them, explaining his ideas on the subject of the proposed reform, exhibiting the principles on which he was about to proceed, and giving, at the same time, a new nomenclature, to which he invited the attention and the criticism of the

[n] See the Memoirs of *Morveau*, *Lavoisier* and *Fourcroy*, read before the Royal Academy on this subject, in ST. JOHN's *Method of Chemical Nomenclature, &c.* 8vo. London. 1788.

philosophical world. After this publication by MORVEAU, several years elapsed before any thing decisive was done. He continued to labour in the improvement of his nomenclature; but at length, sensible of the magnitude and difficulty of the undertaking, he determined to avail himself of the advice and assistance of the members of the Royal Academy. For this purpose, he particularly associated with himself Messrs. LAVOISIER, BERTHOLLET, and DE FOURCROY. These four gentlemen, after spending much time on the subject; after combining their learning and wisdom in many patient consultations;[o] at length, in the month of April, 1787, presented to the academy their new *antiphlogistic theory*, accompanied with a new nomenclature, made out on the principles before laid down by DE MORVEAU, and which were both, in a few weeks afterwards, published to the world.[p] About the same time was published a new table of symbols and chemical characters, by Messrs. HASSENFRATZ and ADET, formed upon the principles of the proposed system, and fitted to illustrate the learned labours of their countrymen, which it accompanied. This table is generally supposed to contain many improvements on those of GEOFFROY, BERGMAN, and CULLEN.

To give in detail a distinct account of all the changes included in this new plan, would far exceed the limits prescribed to the present sketch. The following brief statement may suffice. STAHL and his followers had always supposed the *metals* to be compound substances, made up of a certain

o See the *Journal de Physique*, for the month of May in that year.

p This body of chemical doctrines is sometimes called the *Lavoisierian* system. Considering the agency he had in its formation, this is scarcely ascribing too much to LAVOISIER: for though many of the leading experiments on which the theory is founded were made by others, yet the task of digesting, arranging, and combining the whole into a consistent and regular system, was principally performed by him.

calx or earth, and *phlogiston;* but the new theorists, believing that there was no proof of such composition, set them down in their tables as *simple bodies* The advocates for the former hypothesis had long contended that *sulphur, phosphorus, azotic* air, and various other substances of a like kind, were also compounds; whereas the believers in the new system took for granted that such composition could not be proved. In the old doctrine, *water* was placed among the simple bodies; but by the experiments of CAVENDISH and others, it was thought sufficient evidence had been given, that it is a compound substance. According to the former theory, the acid principle was considered a compound of earth and water; the only radical acid in nature was supposed to be the *sulphuric,* and all others different combinations of this primitive one: while, according to the latter doctrine, the acids are many in number, and result from the union of *oxygen* to different acidifiable bases. In short, while the disciples of STAHL undertook to account for almost all the phenomena of chemistry by the aid of *phlogiston,* the associated Academicians considered it as a creature of the fancy, which had no real existence; and taught that all the facts and appearances in this science may be more satisfactorily explained without the aid of this imaginary substance. To these particulars it may be added, that, in this new theory, the number of chemical objects is greatly increased, and that articles which had occupied an inferior place in the old tables, are here made to hold a more conspicuous and important station.

The *nomenclature* in which this new theory was clothed also deserves our notice. It was formed on the five following principles, laid down by MORVEAU in the memoir above mentioned, viz. 1. That every substance should be denominated

by a *name* and not by a *phrase*. 2. That the names should be, as much as possible, expressive of the *nature* of the things intended to be signified by them. 3. That when the character of the substance to be named was not sufficiently known to determine on a denomination expressive of its nature, a name without meaning should be preferred to one which might give an erroneous idea. 4. That in the choice of new denominations, those which had their root in the most generally known dead languages, should be preferred, in order that the word might be suggested by the sense, and the sense by the word. And, 5. That the denominations should be arranged with care, to suit the genius of the language for which they were proposed. In conformity with these principles, the new terms introduced were taken, for the most part, from the *Greek* language; some from the *Latin*, and a few are formed by a mixture of syllables from each; and that the change might not be carried to an unnecessary extent, as many of the old names were retained as could be made to incorporate with the new system. These denominations were arranged in systematic order; and the whole plan so constructed, that the substances brought to light by succeeding discoveries might be placed under their proper heads, without derangement or disadvantage.

For some time after its publication, this new system of doctrines and of nomenclature was received by French chemists only, and indeed was by no means without opposition, even among them. Some members of the Academy entered their protest against it, in moderate and respectful, but firm language.[q] While they acknowledged

q See their representation in the *Memoirs of the Royal Academy* for June, 1787.

that the *phlogistic* theory was attended with difficulties, they expressed a fear that the *antiphlogistic* plan was attended with as many, and of not less magnitude. Instead of moving to reject it, however, they proposed that it should be submitted to the trial of time, to the test of experiments, and to the elucidating influence of contending inquiries and opinions. This was accordingly done. The Academy gave it to the world, without pronouncing on its merits, and it soon became the popular system of France.

The next year after the publication of the new theory and nomenclature by the Royal Academy, they were exhibited in an English dress, and began to be more generally studied than before by British chemists. Among these the number of converts to the improved doctrines and language soon became considerable. But this favourable reception was by no means universal. Dr. BLACK, Dr. PRIESTLEY, Mr. KIRWAN, and Mr. KEIR, with a few other conspicuous characters, took their stand among the opposing party, and several of them wrote largely and ably against the new opinions and terms. It is obvious that any system opposed by such men must have serious obstacles to encounter. But the system in question made its way with wonderful success, amidst all opposition. Early in the year 1791 Mr. KIRWAN, after combatting in defence of phlogiston for a long time, and with admirable prowess, laid down his arms, and declared himself a convert to the new doctrine. In the same month Dr. BLACK gave up his objections, and went over to the antiphlogistian ranks. And among all the distinguished British chemical philosophers, Dr. PRIESTLEY and Mr. KEIR alone adhere to the opposition with which they set out. The former, especially, it must be acknowledged, has defended the phlogistic citadel

with a degree of skill, firmness and force, and has displayed an extent of resources, and a dignified zeal in the warfare, which must do him immortal honour among all to whom science is dear.

Dr. PRIESTLEY has uniformly continued to object that the fundamental principles of the new theory are erroneous, and that, of course, much of its language is altogether improper. He contends, with unabating confidence, that the *metals* are compound bodies; that *water* is a simple substance; that fixed air is formed by the union of inflammable and dephlogisticated airs; that phlogisticated air, or *azote*, is not a simple but a compound substance; that the antiphlogistic doctrine rests upon a foundation narrow and precarious, and professes to derive its support from experiments few in number, ambiguous in their nature, and explicable, on either hypothesis, with nearly equal ease; and, on the whole, that discarding phlogiston is so far from diminishing the difficulties of the chemical inquirer, that it multiplies and extends them.[r] In defending each of these positions, this illustrious veteran in science has undoubtedly exhibited astonishing industry, as well as great erudition and acuteness. How far the result of the controversy will justify his perseverance, it is difficult, and would certainly be presumptuous in one comparatively little acquainted with the subject, to predict. But when so great a majority of the philosophical world agree in supporting the doctrines which he opposes, it is, perhaps, rather more probable that the phlogistic theory will be ultimately pronounced the weaker. At all events, however, he is abundantly entitled to the honour of having made the best of his cause.

In Germany, and the neighbouring countries on

r See his late work, *The Doctrine of Phlogiston established*, &c.

the continent, the French doctrines and nomenclature made their way rather more slowly than in Great-Britain. Nearly two years after they had met with a general reception among the British chemists, they were introduced to those of Germany, chiefly by VAN MONS and GIRTANNER. They were received, on this introduction, in a favourable manner, and after surmounting the first prejudices, which a change so radical and extensive is always apt to excite, soon became generally popular. Since that time the prevalence of the new system has become almost universal. Indeed, there is no example, since the revival of learning, of a theory being more promptly and generally received, or defended with more ability and zeal, by the great body of philosophers, in all parts of the world, than this. If we except Dr. PRIESTLEY, Mr. KEIR, and the *Lunar Society* of Birmingham, in Great-Britain; M. SAGE, and a few others, in France; and CRELL, MAYER, GMELIN, and WESTRUMB, in Germany, we now hear of no distinguished advocates for the old opinions.

Besides the signal revolution in chemical theory which has been stated, every part of the century under consideration, and especially the latter half of it, has abounded in experiments and discoveries of great importance, particularly when considered with reference to their systematic relations.

The experiments and discoveries with respect to *heat*, or the substance lately denominated *caloric*, have been very numerous within the period in question, and hold a very important place in the chemical history of the age. It was before observed, that, at the beginning of the century, *heat* seemed to be considered, by a great majority of the most eminent philosophers, as a mere *property* of matter, like gravity or mobility, and as consisting in a peculiar kind of *vibration* of the par-

ticles of matter. BOERHAAVE was one of the first distinguished philosophers who taught, in opposition to NEWTON and others, that it was a *distinct substance.* This doctrine was soon afterwards embraced by many others, and has been since generally received. Those who considered heat as a mere property of matter, were at no small difficulty to account for *cold,* which BOERHAAVE, and those who followed him, supposed to consist merely in the *absence of heat.* Some, in order to avoid this difficulty, supposed cold to arise from the presence and operation of *frigorific particles.* MUSCHENBROECK, a celebrated Dutch philosopher, was among the last of those who distinguished themselves as the advocates of this opinion.

After BOERHAAVE, the most eminent defenders of his leading doctrine with respect to heat were Dr. CRAWFORD, Dr. BLACK, Mr. MAGELLAN, and Dr. IRVINE, of Great-Britain, Mr. KIRWAN, of Ireland, Messrs. LAVOISIER and DE LA PLACE, of France, and Messrs. DE LUC, DE SAUSSURE, and PICTET, of Geneva. It would be inconsistent with our limits to attempt even a sketch of the experiments and discoveries made by these celebrated philosophers. Among the most important of them we may reckon the doctrine respecting *latent heat,* before mentioned as having been published by Dr. BLACK, in 1757, which doubtless led the way to most of the subsequent discoveries in this part of chemistry, and in a great measure changed the face of the science. The invaluable instruction which it affords respecting *combustion, fluidity, evaporation,* &c. is well known. The facts brought to light concerning *specific heat,* or the different capacities of bodies to imbibe and retain this substance, first by Professor WILCKE, of Stockholm, and afterwards, in succession, by Drs. BLACK, IRVINE, and CRAWFORD, and by Messrs. KIRWAN,

MAGELLAN, LAVOISIER, and DE LA PLACE, are important, and have contributed not a little to the progress of chemical knowledge. The power of heat to *expand* different bodies has been investigated during this period, and received more satisfactory illustration than ever before, by many philosophers, particularly by DE LUC, KIRWAN, DU VERNOIS, RINMAN, and SMEATON. The experiments made, within a few years past, on the power of different mixtures to *produce cold*, or, in other words, to reduce heat to a *latent* state, are instructive and interesting. The inquiries respecting the power of different bodies to *conduct heat*, by INGENHOUZ,[s] SENNEBIER,[t] Count RUMFORD,[v] and others, form important steps in investigating the nature and properties of this fluid. And, finally, the experiments of LAMBERT, SCHEELE, PICTET, and Count RUMFORD, on *radiant* heat, and those of Dr. HERSCHEL, showing the different *refrangibilities* of the rays of heat, as well as of light, and the different *temperatures* of the latter,[u] may all be considered as very valuable additions to the science of chemistry.

The inquiries of modern chemists into the nature and properties of *light* have been scarcely less numerous and interesting. Those discoveries respecting this substance which fall under the science of *optics*, have been mentioned in another place. The capacity of other bodies to receive light, to

s *Journal de Physique*, 1789, p. 68.

t *Ibid.* 1788.

v RUMFORD's *Essays*, and *Philosophical Transactions* for 1792. This great practical philosopher is an American. He was born in the State of Massachusetts, and left his native country a short time before the close of the revolutionary war. Finding in Europe favourable opportunities for cultivating and displaying that genius which had begun to manifest itself in his native land, he has done equal honour to himself, and to the country which gave him birth, by devoting this genius to such inquiries as have a tendency to promote the welfare and happiness of man.

u *Philosophical Transactions* for 1800.

retain it in a *fixed state*, and afterwards to part with it, without alteration, was discovered by the experiments of Father BECCARIA, Mr. CANTON, Mr. WILSON, and M. DE GROSSER. The affinity between light and heat, and the similarity of their effects, in certain cases, have been diligently investigated by Dr. FRANKLIN, Mr. WEDGEWOOD, Messrs. PICTET, CHAPTAL, and DORTHES, and especially by Count RUMFORD and Dr. HERSCHEL. The researches of M. BERTHOLLET and of Dr. BANCROFT, in the philosophy of *permanent colours*, upon chemical principles, were mentioned in the preceding chapter. The experiments of Dr. PRIESTLEY, the Abbe TESSIER, Dr. INGENHOUZ, and others, on the effects of light upon growing vegetables, and the curious inquiries of HERSCHEL, into the different *heating power* of the different prismatic colours, are also worthy of notice in the list of modern discoveries. The importance of these inquiries, whether considered as insulated facts, or with reference to systematic chemistry, will readily occur to every scientific reader.

The discovery of *oxygenous gas*, or *vital air*, by PRIESTLEY and SCHEELE, was cursorily noticed in a former page. *Hydrogen*, or *inflammable air*, had been before observed, but its properties were first examined by Mr. CAVENDISH,[w] in 1766, and afterwards more fully investigated by PRIESTLEY, SCHEELE, FONTANA, KIRWAN, DE MORVEAU, HASSENFRATZ, and others. The various combinations of this substance, especially with *phosphorus* and *carbon*, were first successfully examined by M. GENGEMBRE and Mr. KIRWAN, and by the associated Dutch chemists BONDT, DIEMAN, VAN TROOSTWYCK, and LAUWERENBERG. *Azotic air* was discovered in 1772, by Dr. RUTHERFORD;[x]

[w] *Philosophical Transactions* for 1766.

[x] See his Dissertation, *De Aere Mephitico*, Edin. 1772.

since which time its qualities have been more fully developed by SCHEELE, LAVOISIER, GOETTLING, CAVENDISH, HILDEBRANDT, LAMPADIUS, and several other distinguished chemists.[y] In 1769 Mr. GAHN, of Sweden, discovered that *phosphorus* was contained in *bones*, and his countryman SCHEELE, very soon afterwards invented a method of obtaining this substance from them. The properties of *phosphorus* have been also more successfully investigated, during this period, than ever before, by MARGRAAF, MORVEAU, LAVOISIER, and PELLETIER. The properties and combinations of *carbon* have been very ably examined, within a few years past, by many eminent philosophers. The power of this substance to correct impurities, and to remove disagreeable odours, has been shown by the experiments of Mr. LOWITZ, of Petersburgh, and several others. The discovery by Mr. TENNANT, that the *diamond* is pure *carbon* in a state of *crystallization*,[z] is by no means a small or uninteresting step in the progress of chemical science. Dr. BLACK first gave the denomination of *fixed air* to a compound of *carbon* and *oxygen*, in a gaseous state, but without understanding its component materials. Mr. KEIR first concluded that this species of air was an *acid*, which opinion was soon afterwards confirmed by the experiments of BERGMAN, FONTANA, and others. Further inquiries into its nature were instituted with considerable success, by Dr. PRIESTLEY and Mr. BEWLY, and by Messrs. DE MORVEAU, PROUST, and LAVOISIER. And, finally, the composition of this gas

y The late ingenious Dr. GIRTANNER supposed that his experiments proved *azote* to be not a *simple* substance, as the French academicians held it, but a *compound*, formed of the same materials with water, in different proportions, and differently modified. If this be the case, the fact will go far toward unsettling an important doctrine of the French system. See *Medical Repository*, vol. iv. p. 192.

z *Philosophical Transactions* for 1797.

was fully demonstrated, *synthetically* as well as *analytically*, in a course of ingenious experiments, by Dr. PEARSON, of London.[a]

Since the commencement of the eighteenth century, a number of new *metals* have been discovered, and the affinities and other properties of metallic substances in general have been better understood than before. Those who most eminently distinguished themselves in this department of chemistry, were MARGRAAF, CRONSTEDT, KLAPROTH, SCHEELE, BERGMAN, VAUQUELIN, KIRWAN, PROUST, SAGE, and LAVOISIER; to which might be added many other names. New *earths* have been discovered, and their chemical properties ascertained, by several of the able chemists last mentioned, and also by BLACK, GAHN, HOPE, CRAWFORD, and WEDGEWOOD. That class of chemical substances denominated *alkalies*, has been better understood, of late years, than in the preceding century. For our knowledge of this department of the science in question we are particularly indebted to the investigations of DU HAMEL, BLACK, MEYER, PRIESTLEY, DIEMAN, VAN TROOSTWYCK, BONDT, BERTHOLLET, and AUSTIN. Modern chemists have also discovered many new *acids*, and thrown much new light on the nature and principles of *acidity*. LAVOISIER first proved that *oxygen*, united to certain bases, formed *acids*: he therefore concluded that this substance is the great *acidifying* principle; and showed, by a number of ingenious and accurate experiments, that when it is taken away, the base from which it is separated loses its acid properties. The most distinguished discoverers of new acids, and of new properties in those before known, were MACQUER, SAUVAGES, MARGRAAF, BERGMAN, KEIR, LOWITZ,

[a] *Philosophical Transactions* for 1793.

GRUTZMACHER, LA GRANGE, and, above all, SCHEELE, whose experiments on acids were probably more numerous, and more instructive than those of any other chemist.

It was not till the century under review that chemical analysis was applied to investigate the composition of *animal* bodies. This has been attempted by a number of modern chemists, and with very honourable success. Among these, the inquiries of SCHEELE, GREN, FOURCROY, and GIRTANNER, are entitled to very respectful notice. But the elaborate researches of Mr. HATCHET, in this interesting field of inquiry, are particularly well known, and do equal honour to his industry and acuteness.[b] The same department of chemistry has also been pursued, with great success, by M. MERAT GUILLOT[c] and others. These investigations have led to important discoveries, have thrown much light on the animal œconomy, and furnished many indications for the improvement of medicine and surgery.

Though *vegetable physiology* had been studied with some degree of success, by several persons, in the seventeenth century; yet, pursuing this species of inquiry through the medium of chemistry was scarcely thought of, and far less realized, till the eighteenth. Within a few years past chemists have directed much attention to the structure, composition, and food of plants; have greatly extended, by this means, the limits of the science; and have contributed much to the improvement of botany, agriculture, the materia medica, and various arts of life. Among those who have displayed the greatest acuteness, zeal, and success in this department of chemical inquiry, we may

b *Philosophical Transactions* for 1799 and 1800.
c *Annales de Chemié*, tom. xxxiv. p. 68.

reckon Dr. HALES and Dr. PRIESTLEY, of Great-Britain, Dr. INGENHOUZ, of Germany, M. SENNEBIER, of Geneva, and several others.

The employment of chemistry by the *mineralogist*, as a means of analysing the various substances which come before him, was first undertaken in the century under review. MARGRAAF and POTT, of Berlin, were among the earliest adventurers in this new field of inquiry. They were succeeded by NEUMANN, BERGMAN, and SCHEELE, who displayed great industry, address, and perseverance, in the same course of investigation, and went much further than their predecessors. To these may be added KLAPROTH, SAGE, VAUQUELIN, and many more, to whom we are indebted for many new facts, and refined experiments, on the chemical properties of mineral bodies.

Since the grand revolution in chemical doctrines and language, effected by the labours of the French Academicians, as above detailed, the new opinions, and the proposals of further reform in this science, have been numerous. Indeed, during the last fifteen or twenty years of the century, the number of students and experimenters in chemistry has been so prodigiously great, and the new plans announced for explaining and expressing its principles so multiplied and various, that a simple catalogue of them would fill many pages. All that can be attempted in this brief sketch, is to mention a few of those who have rendered themselves conspicuous by their inquiries or publications on chemical subjects.

A new nomenclature of chemistry was proposed, in 1796, by Professor DICKSON, of Trinity College, Dublin, and approved by his illustrious countryman, Mr. KIRWAN. In this plan of chemical denominations there is an attempt to unite the advantages of both the principal systems, between

which the philosophical world was then called to choose. Many of the old names, discarded by the French Academicians, are restored by Dr. DICKSON; while many substances, to which names are given by them, he has left out, as not sufficiently understood. He derives his new terms chiefly from the *Latin* instead of the *Greek* language. And he prefers that mode of arrangement and classification which consigns the generic rank to *alkalies*, *earths*, and *metals*, and reserves the *acids* for the distinction of species. He retains, however, *oxygen*, and a few other words of Greek derivation. The advantages which, in the opinion of the Irish Professor, would arise from the adoption of this nomenclature, are, that the old books on chemistry would thereby be more readily understood, and more valuable; and that the acquisition of the science would be more simple and easy. Dr. DICKSON's plan, though it undoubtedly does no small honour to his learning and taste, has not, it is believed, been adopted by any distinguished teacher of this branch of philosophy.

It is proper also to take notice of a plan, by Dr. LUBBOCK, of Great-Britain, for removing the difficulties, and terminating the controversy respecting *phlogiston*. His idea of dividing all matter into two kinds, the *principium proprium*, and the *principium sorbile*, and of accounting for all chemical phenomena by the combinations of these, is very ingeniously defended in his work on the subject.[d] No less worthy of respectful notice is Mrs. FULHAME's attempt to correct the *antiphlogistic* theory, by referring to water as the source of oxygen in all oxydations; a very honourable monument of female enterprize and talents.[e] The

d *Dissertatio Physico-Chemica, de Principio Sorbili.*
e *Essay on Combustion.*

plan of a new nomenclature, by M. WEIGLIR, a German chemist, also indicates considerable learning and ability.[f] To these may be added some proposed alterations in the French nomenclature, by Dr. PEARSON,[g] before mentioned, and by several other ingenious writers. Though none of these authors can be said to have produced revolutions in the science of chemistry; nor, perhaps, to have suggested very important improvements; yet they are entitled to a respectful notice in the chemical history of the age.

In the course of the last six years, Dr. MITCHILL, the ingenious and learned Professor of Chemistry in Columbia College, has proposed some new terms in this science, and announced some new opinions, of which it will be proper to take notice.

His doctrine of *pestilential fluids*, which has been laid before the public in various forms since 1796, holds the first place, both with respect to time and importance. He supposes that the union of *azote* and *oxygen*, either in the form of *oxyd* or *acid*, and more especially in the latter, constitutes the mischievous substance which, in its operation on the human body, produces pestilence. In correspondence with which opinion, he teaches that *alkaline* and *calcareous* remedies are the most effectual means of disarming the force, and obviating the destructive effects of this poison. At the same time the Professor proposed an alteration in the nomenclature, agreeing with his new doctrine, and illustrative of its principles. Considering *azote* as having an important agency in the process of *putrefaction*, he proposed to introduce the word *septon*[h] instead of *azote*, and hence denominated

f Encyclopædia, art. *Chemistry.*

g See his View of the French Nomenclature. 4to. 1799. London.

h This word is derived from σηπω, *putrefacio:* hence σηπτος, *putridus*, and τὸ σηπτον, *what peculiarly disposes bodies to rot.* Medical Repository, vol. ii. p. 50.

the deleterious compounds above mentioned the *oxyd of septon*, and *septic acid*. The various facts and reasonings adduced by the Professor in support of these opinions, and the extensive application of which he considers them as susceptible, have been so generally made known and discussed, both in Europe and America, as to preclude the necessity of giving further details.

In 1797 Dr. Mitchill, with a view to terminate the controversy between the *phlogistians* and their opponents, proposed to expunge *hydrogen* from the nomenclature, and to introduce *phlogiston*[i] in its place. He suggested, that giving this old and popular name to a known and definite substance, instead of using it in its former vague manner, and ascribing to this substance those qualities which had been formerly ascribed to a non-entity, would go far toward reconciling many points of difference between the advocates of the old and the new systems, and would throw much light on many chemical phenomena. The same gentleman soon afterwards proposed to discard the term *calorique*, adopted by the French Academicians, and to substitute the word *anticrouon*[j] in its stead. He supposed, that denominating the matter of heat the great *principle of repulsion*, would lead to more correct philosophical views with respect to this substance, as well as render the language of chemistry more accurate. These several opinions and proposals have been some time before the public; and whatever may be the ultimate judgment of chemists with regard to their adoption, the praise of great learning, ingenuity

i Derived from Φλογιζω, *inflammo:* hence τὸ Φλογιςτον, *the principle of inflammability*, or that which, in any substance, *burns with blaze.*

j Derived from the verb αντικρουω, *repello:* hence τὸ αντικρουον, *the principle of repulsion.*

and industry, must undoubtedly be given to their author.[k]

Besides the revolutions and improvements in the doctrines and in the language of chemistry which have been detailed, various *instruments* and *machines*, of great value, for measuring chemical substances, or facilitating chemical processes, have been invented in the course of the last century. Of some of the most important of these it will be proper to give a short account.

At an early period of the century, while speculations on the nature and properties of *heat* engaged the attention of the philosophical world, various contrivances for measuring this fluid were invented and adopted. The *Thermometer*, which had been first used about the beginning of the preceding century, was constructed on a new and improved plan, by Sir ISAAC NEWTON, in 1701. He chose, as fixed points of graduation, those at which water freezes and boils; a choice which the experiments of succeeding philosophers have proved to be the most wise and convenient. He also introduced the use of *oil* to fill the tube, instead of *alcohol*, under an idea that the former was liable to fewer disadvantages than the latter. But, after all the labours of Sir Isaac, this important instrument was imperfect, and could by no means be considered as an exact standard for pointing out the various degrees of temperature. Accordingly, about the year 1724, Mr. FAHRENHEIT, of Amsterdam, suggested the use of thermometers made with *mercury*, and presented one

k Those who wish to see a more detailed account of Dr. MITCHILL's new chemical opinions and terms, will find it in his *Explanation of the Synopsis of Chemical Nomenclature and Arrangement*, &c. lately published. Much information on this subject may also be found in the volumes of the *Medical Repository*, and in several of the European journals. In these publications the reader will see the respectful manner in which the inquiries of the learned Professor have been noticed in different parts of Europe.

of this kind to the Royal Society of London. It was soon found that this fluid was preferable to all others, being more homogeneous, more easily freed from air, more regularly expansible by different degrees of heat, and more difficult to congeal. Mr. FAHRENHEIT also proposed a new mode of graduating the instrument. His thermometer has since come into general use in Great-Britain, America, and in the various parts of the world in which British habits prevail.

In 1730 M. REAUMUR, a French philosopher, constructed a thermometer on a new plan. He adopted a mode of graduation different both from NEWTON and FAHRENHEIT, and resumed the use of *alcohol*. His plan was, of course, still far from being perfect. The thermometer now in use in France, and through a great part of the continent of Europe, under the name of REAUMUR's, ought strictly to be called Mr. DE LUC's, who made a very important alteration in Mr. REAUMUR's mode of graduating the instrument, and again exchanged *alcohol* for *mercury*. In 1733 M. DE L'ISLE, of Petersburgh, constructed a mercurial thermometer on the principle of that formed by REAUMUR. This is generally used in Russia. Another, graduated in a different manner, by CELSIUS, and also filled with mercury, is most popular in Sweden.[l]

Besides these leading inventions and revolutions which the history of thermometers presents, the plans which have been suggested in modern times, for improving this instrument, are many and ingenious. These have been successively proposed by Lord CAVENDISH in 1757; by Mr. SIX in 1782; by Dr. RUTHERFORD in 1790; and still more recently by Mr. KEITH, whose new *self-registering*

[l] See MARTINE's *Essay on Thermometers.*

thermometer is said to be the most ingenious, simple, and perfect of any which has hitherto appeared.

It was still, however, an important desideratum to find some easy and exact method of measuring very high degrees of heat. Such a method was not long since invented by Mr. WEDGEWOOD, of Great-Britain, a gentleman well known for his great improvements in the art of pottery. After many experiments,[m] he produced an instrument which he called a *pyrometer*, and which, by means of the contraction of *clay*, marks, with much precision, the different degrees of heat, from 947° of Fahrenheit's scale, to the greatest heat of an air-furnace.

It was first observed by Dr. BLACK, that different bodies have different capacities for imbibing and retaining heat. The fact was afterwards noticed, and the subject further investigated, by Drs. IRVINE and CRAWFORD, and by Professor WILCKE, of Stockholm. The last named gentleman called the quantity of caloric necessary to raise the temperature of substances a given number of degrees, their *specific heat*. For measuring this heat an instrument was contrived by Messrs. DE LA PLACE and LAVOISIER, and called by the latter a *calorimeter*; the nature and value of which will be found exhibited in various books of chemistry.

Another instrument, invented in modern times, and which has engaged much of the attention of chemists, is the *eudiometer*. This instrument was invented by Dr. PRIESTLEY, and is used for ascertaining the purity of the atmospherical air, or the quantity of oxygen contained in it, which is indicated by the diminution of its volume on being

m See *Philosophical Transactions* for 1782, 1784, 1786.

mixed with nitrous air. The discovery of this property of nitrous gas, and the invention founded upon it, soon gave rise to many attempts to improve on the principle, and to contrive *eudiometers* of a more elegant and advantageous kind, and with different materials. These attempts were made, and various plans successively proposed by M. Landriani, Mr. Magellan, M. Fontana, Mr. Cavallo, M. De Saussure, Mr. Cavendish, M. Morveau, and several others. Of these, the contrivances of Fontana and Morveau have been pronounced the best. The latter employs *sulphuret of pot-ash* instead of *nitrous air*, and measures the proportion of oxygen present by the quantity absorbed by the *sulphuret.* But the instrument, in its most favourable form, is still liable to much uncertainty and inaccuracy in its application.

The machine for impregnating water with *carbonic acid gas*, or *fixed air*, invented a few years ago by Dr. Nooth, of Great-Britain, deserves to be respectfully mentioned, as a monument of ingenuity, and as a very useful piece of furniture for every chemist and physician. Besides this, our list might be enlarged by the enumeration of many other instruments and machines which have been added to the chemical apparatus in modern times, and which have greatly contributed to the ease, elegance, and perfection of chemical experiments.

After mentioning the great names, and the brilliant discoveries, which have been recounted in the foregoing pages, it would be unjust to omit taking notice of some other philosophers who have distinguished themselves by their publications or experiments in this branch of science. Among a great number, whose names and labours will be found honourably recorded in the scientific history

of the age, we may mention Bishop WATSON, Mr. NICHOLSON, Dr. ST. JOHN, Mr. HENRY, Mr. PARKINSON, Mr. CRUIKSHANK, Dr. DARWIN, Lord DUNDONALD, Dr. AUSTIN, Mr. LAMBE, Mr. HIGGINS, and Dr. THOMPSON, of Great-Britain; Messrs. CHAPTAL, MONGE, MONNET, D'ARCET, BEAUME, LEMERY, CADET, THOUVENAL, LA METHERIE, ADET, and SEGUIN, of France; and JUNCKER, SCHRŒDER, WENZEL, HENKEL, JACQUIN, MEYER, CRELL, VAN HOMBERG, and HERMSTADT, of Germany; to say nothing of many others, equally entitled to praise, in almost every cultivated part of Europe.[n]

From the above general statements, it appears that within the last half century the empire of chemistry has been wonderfully extended. It is but a short time since this science recognized, as the subjects of her sway, only a few *metals* and *medicines*. She has lately subjected to her sceptre the various kinds of *earths* found in the composition of our globe; the different *fluids* with which we are conversant, whether of the *aqueous* or *gaseous* form; the various kinds of *vegetable*, *animal*, and *mineral* bodies which surround us; and almost every substance capable of composition or analysis. In short, she has extended her claims to every species of *animate* and *inanimate* matter, and maintains authority over a territory of physical science which may be called immense, when compared with her former dominions.

But chemistry has not only gained, during the eighteenth century, a great extent of empire; it is also distinguished for having acquired, in the same period, a more *practical* and *useful* cast than ever

[n] The contributions made to chemical knowledge by most of the above named gentlemen may be found either in distinct works, published by themselves, or in the *Philosophical Transactions*, the *Journal de Physique*, the *Annales de Chemie*, or other scientific journals.

before. By the ancient cultivators of this science it was chiefly regarded as an object of *curiosity*, or as a source of *amusement*. But in the hands of later chemists it has been converted into a most instructive, interesting, and invaluable science. There is scarcely an art of human life which it is not fitted to subserve; scarcely a department of human inquiry or labour, either for health, pleasure, ornament, or profit, which it may not be made, in its present improved state, eminently to promote.

To the *husbandman* this science furnishes principles and agents of inestimable value. It teaches him the *food* of plants; the choice and use of *manures*; and the best means of promoting the vigour, growth, productiveness, and preservation of the various vegetable tribes. To the *manufacturer* chemistry has lately become equally fruitful of instruction and assistance. In the arts of *brewing*, *tanning*, *dyeing*, and *bleaching*, its doctrines are precious guides. In making *soap*, *glass*, *pottery*, and all *metallic* wares, its principles are daily applied, and are capable of still more useful application as they become better understood. Indeed, every mechanic art, in the different processes of which heat, moisture, solution, mixture, or fermentation are necessary, must ever keep pace in improvement with this branch of philosophy. To the *physician* this science is of still greater value, and is daily growing in importance. He learns from it to compound his medicines; to disarm poisons of their force; to adjust remedies to diseases; and to adopt the general means of preserving health. To the student of *natural history* the doctrines of chemistry furnish instruction and assistance at every step of his course; as many of his inquiries can be prosecuted with success only through the medium of careful analysis. To the

public economist chemistry presents a treasure of useful information. By means of this science alone can he expect to attack with success the destroying pestilence, so far as it is an object of human prevention, and to guard against other evils to which the state of the elements gives rise. And in order to the prosecution of numberless plans of the philanthropist to any extent or effect, some acquaintance with the subject in question seems indispensably necessary. Finally, to the *domestic economist* this science abounds with pleasing and wholesome lessons. It enables him to make a proper choice of *meats* and *drinks;* it directs him to those measures with respect to *aliment, cookery, cloathing*, and *respiration*, which have the best tendency to promote health, enjoyment, and cheapness of living; and it sets him on his guard against many unseen evils, to which those who are ignorant of its laws are continually exposed. In a word, from a *speculative* science, chemistry, during the eighteenth century, has become eminently and extensively a *practical* one; from an obscure, humble, and uninteresting place among the objects of study, it has risen to a high and dignified station; and instead of merely gratifying curiosity, or furnishing amusement, it promises a degree of utility, of which no one can calculate the consequences, or see the end.

But while the great improvements which have been made in *chemical* philosophy during the last century are readily admitted, it may not be improper, before closing this chapter, to take notice of the gross abuses which have been adopted by some of the most celebrated cultivators of the science in question, and which have contributed to lessen its value in the view of many serious inquirers. A few extravagant and enthusiastic votaries of chemistry have undertaken, on chemical princi-

ples, to account for all the phenomena of *motion, life,* and *mind;* and on those very facts which clearly prove wise design, and the superintending care of an INFINITE INTELLIGENCE, have attempted to build a fabric of *atheistical* philosophy. This is a remarkable instance of those *oppositions of science falsely so called,* of which an inspired writer speaks, and for which the past age has been remarkably distinguished.

How far the present fashionable system of chemical doctrine and language may stand the test of future experiments, and command the assent of future generations, is far from being certain. He who has attended to the course of things in the short space of time since it was published, will see little reason to expect for it that undisturbed and permanent reign which its advocates have fondly hoped. It is somewhere remarked by Lord BACON, that the sciences are apt to suffer by being too soon reduced to a system. There are probably few sciences to which this remark applies with such peculiar force as to chemistry. The structure at present most popular is fair and beautiful. An engaging simplicity reigns in almost every part. But many believe that this simplicity is deceptive. Some of the doctrines which hold an important place in the fabric are too vague and conjectural to be admitted with full confidence, and others are daily undergoing modifications, which threaten still further and more essential changes. Notwithstanding the mathematical precision with which the sanguine chemist affects to speak of his axioms, yet how discordant are the results of different experiments! These facts, it must be acknowledged, "betray the lameness of some received principles, and excite suspicions with respect to the legitimacy of some capital analyses." But the enlightened and enterprizing

philosopher will not be discouraged by such proofs of the imperfection of human knowledge. The builders of erroneous systems become indirectly the promoters of truth, by contributing to the examination and rejection of falsehood. We can only hope, in the present world, to be continually approximating toward the point of complete philosophic illumination, without ever reaching it; and this approximation must always be made through successive defiles of illusion, empiricism, and false theory. In this course honesty, attention, and patient perseverance, are the great requisites for obtaining success. With these, though we cannot expect to develope all the mysteries of nature, which is the prerogative of its AUTHOR alone; yet we may hope, in time, to detect analogies, to ascertain laws, to systematize scattered facts, and to unlock treasures of science, which appear at present far removed from human scrutiny, and against the knowledge of which the feebleness of our powers seems to raise everlasting barriers.

CHAPTER III.

NATURAL HISTORY.

THIS department of science scarcely yields to either of the preceding in the extent and value of the improvements which it has received within the period under consideration. Many of the objects, indeed, to which natural history relates, have been, in some degree, known and studied by man, from the earliest ages, as means of sup-

plying the wants, and obtaining the luxuries of life. SOLOMON, the king of Israel, we are told, *spake of trees, from the cedar tree that is in Lebanon, even unto the hyssop that springeth out of the wall:—he spake, also, of beasts, and of birds, and of creeping things, and of fishes.*[o] And, if we may judge from the respectful terms in which such studies are mentioned, in this and in various other passages of sacred scripture, we may conclude they were held in high estimation in very early times. It was not, however, until long after the revival of letters and science in Europe, that natural history began to receive the attention due to its importance. Toward the close of the seventeenth century, after several learned societies in Great-Britain, and on the continent, had been formed, the taste for this branch of study commenced, and has been ever since gradually extending itself over the civilized world.

At an early period of the eighteenth century, many persons were busily employed in collecting and publishing facts in Natural History, especially in *Zoology* and *Botany*. But though these inquirers rendered important service to this department of philosophy, it was rather by communicating a knowledge of details, than by enlightened and correct philosophizing on the subjects which came before them. Scarcely any thing had been effected, on a great scale, previous to the appearance of LINNÆUS, an illustrious Swede, who, by his first publications, in 1735, gave a new aspect to the whole science, and commenced what has been with much justice styled the "golden age" of Natural History.—Almost every thing that had been done in the great business of *Classification*, before his time, was confused, and ex-

o 1 *Kings* iv. 33.

ceedingly defective; and, in some of the kingdoms of nature, few attempts of the kind had been made. It is not necessary to remind the intelligent reader how much this deficiency must have perplexed and retarded the inquirer, at every step of his course. It was reserved for LINNÆUS, a man equally distinguished for the benevolence and piety of his heart, the extent of his learning, and the greatness of his views, to remedy the defect. To his luminous and expanded mind, the arduous task of generalizing and arranging seemed to be an easy and familiar process. He introduced new methods of classification into all the more important branches of natural history; made large additions to its known facts and principles; excited a thirst, before unequalled, for this kind of knowledge; and prepared the way for a great portion of the improvements which have been made by succeeding naturalists.

While the last age produced much new light in the philosophy of natural history, and added immense riches to its former stores, it also gave to this science new distinction as an object of study in seminaries of learning.—At the close of the seventeenth century, it is believed, few *professorships* had been instituted, even in the most distinguished universities, for instructing youth in this interesting department of knowledge. Since that time few important colleges or universities have failed to add such professorships to their former plans of instruction, and to place natural history among the indispensable objects of attention in an academic course. By these and other means new honours have been bestowed on this branch of science, new encouragement given to the zeal and exertions of inquirers, new roads to improvement opened, and new opportunities afforded, at once, of diffusing a taste for investi-

gations of this nature, and of extending the information which genius and industry had gained.

But it will be more satisfactory to take a brief view of the several kingdoms of nature, and to state some leading facts concerning the progress which has been made in each.[p]

ZOOLOGY.

At the beginning of the eighteenth century considerable progress had been made in this branch of Natural History, by the inquiries and discoveries of HARVEY, REDI, MALPIGI, WILLUGHBY, and RAY. These illustrious men discarded several erroneous doctrines which had long been received, particularly the doctrine of *equivocal generation*, and threw much light on the principles of physiology. RAY, being dissatisfied with ARISTOTLE's classification of animals, invented a new one, founded on the structure of the *heart*. To this he was particularly led by the discoveries of HARVEY, relating to the *circulation of the blood*, which had been a little before announced, and excited much attention in the philosophical world. From the time of RAY till that of LINNÆUS, little progress was made in Zoology. A few books, during this interval, were published on the subject; but they did little more than make some inconsiderable additions to the number of facts before known. The achievements of the celebrated Swedish Professor in this, as well as in the other branches of natural history, cannot be contem-

[p] The contents of this chapter have been principally collected from SMITH's *Tracts on Natural History*, and various other works, on detached parts of the subject; some of which will be found quoted, or referred to, in the following pages. For a knowledge of some of the facts and names here detailed, I am indebted to Professor BARTON, of Philadelphia, who, in a conversation on the subject, furnished me with much valuable information, and with profitable hints for directing my inquiries.

plated without admiration. He described many new animals, and formed a new arrangement and nomenclature, in many respects original, and in general greatly superior to any that had gone before him. From this period writers on the various departments of the animal kingdom began rapidly to increase in number, in the extent of their information, and in the accurate and philosophical aspect of their descriptions.

Soon after LINNÆUS appeared M. KLEIN, of Dantzic, who warmly opposed a number of the alterations proposed by that illustrious naturalist, and signalized himself as his adversary. KLEIN gave to the world a new method of classification, founded on the *toes*, *hoofs*, &c. and by his multifarious works, on almost every department of zoology, which he treated both systematically and physiologically, rendered very important service to the science. About the same time flourished M. BRISSON, a French naturalist of very high character, and whose publications, particularly on *Quadrupeds* and *Birds*, rank in the first class on their respective subjects. Indeed, in the accuracy of his descriptions, and the excellency of his plates, he may even be pronounced superior to LINNÆUS himself. After BRISSON may be mentioned his countryman the Count DE BUFFON, who, though more sprightly and interesting as a writer, in which he excels all other natural historians, is far less accurate and philosophical. His neglect of regular systematic arrangement is a great defect, and must ever lessen the value of his works. He was a zealous cultivator of zoology, and by his splendid publications and captivating style made himself admired throughout the scientific world. And though many of his hypotheses are whimsical, extravagant, and delusive, it must yet be allowed that he did much to encourage and forward the study of nature;

that he made many observations of great value; that he collected a multitude of interesting facts; and that his works hold a very important place in the zoological history of the age.

Contemporary with BUFFON was Mr. PENNANT, of Great-Britain, who is unquestionably entitled to a place among the greatest zoologists of the eighteenth century. By his writings, as valuable as they are voluminous, he contributed greatly to the advancement of this branch of natural history. He was the author of a new arrangement of *Quadrupeds*, more nearly resembling RAY's, of the former century, than any other. On this subject his work may be pronounced equal to any, if not the best that has yet been presented to the student of nature. Within the same period, Professor BLUMENBACH, of Goëttingen, distinguished himself by his zoological and physical inquiries, and particularly by a new method of arranging *Quadrupeds*. To these great names may be added that of Professor PALLAS, of Petersburgh, who, in zoology, as well as in several other branches of science, has done much, and is to be considered as ranking with the very first, if not as standing at the head of all the naturalists now living.

Besides these distinguished systematic writers on the subject of zoology in general, particular departments of the science have been cultivated, and greatly improved, by men scarcely less eminent, or less worthy of praise. Of some of these inquiries and publications a brief notice will be attempted.

It is proper to begin with the natural history of the *first* Linnæan class, the *Mammalia*. On this class almost all the great writers whose names were just mentioned, have made large and instructive publications. In addition to what has been accomplished by them, especially by LINNÆUS, KLEIN,

PENNANT, and BUFFON, the labours of Professor E. ZIMMERMAN, of Brunswick, to throw light on this class of animals, do him great honour. His conception and execution of a *Zoological Chart*, accompanying his work on the *Mammalia*, may be considered as one of the most philosophical productions of the age. This ingenious invention has been extended and improved by M. JAUFFRET, a distinguished naturalist of France. Beside these, many others deserve notice for their successful labours in illustrating particular parts of this extensive field of inquiry.

Much has been done, during the last century, toward completing the natural history of *man*. In the list of experimenters and authors on this subject, ALBINUS, a Dutch naturalist, holds the first place, with respect to time. He was a very great anatomist; and was one of the first who attended, in a scientific manner, to the seat of *colour* in human beings. The next important publication, on the same branch of natural history, was by the celebrated JOHN REINHOLD FORSTER,[q] who threw considerable light upon it. He was followed by the Rev. Dr. SMITH, President of the College of New-Jersey, who, in his ingenious and learned *Essay on the Causes of the Variety of Complexion and Figure in the Human Species*,[r] gave a very instructive and interesting view of the subject. The natural history of man has also been treated in a more general way by BUFFON and VEREY,[s] of France; by BLUMENBACH,[t] ZIMMERMAN,[v] LUD-

q See FORSTER's *Observations*, &c. 4to. 1778.

r Dr. SMITH's *Essay* was favourably received not only in his own country, but also in Great-Britain, and on the continent of Europe, where several editions of it were circulated, in the English, French, and German languages.

s *Natural History of Man*, &c. 2 vols. 8vo.

t *De Generis Humani Varietate Nativa*, &c. Goëttingen, 1795.

v *Geographical History of Man*, &c. 8vo. 3 vols. Leipsic, 1778.

WIG,[u] and SOEMERING,[w] of Germany; and by Professor PALLAS, of Russia. To which may be added the great anatomical discoveries and improvements, by the MONROS, CAMPER, the HUNTERS, DAUBENTON, BOURGELAT, and many others.

It will not be improper here to take notice of some of the writings of Sir WILLIAM JONES, as calculated to throw much light on the natural history of man, through the medium of inquiries concerning language, habits, religion, &c. The various and valuable instruction which the discerning student of this branch of science may derive from those writings, is too obvious to require explanation. The general philosophy of man has been considered, in a different view, in the celebrated but erroneous publications of HARTLEY and HELVETIUS. A late work on the *Physical History of Man*, by MEINERS, of Germany, and another, entitled *Outlines of the History of Man*, by HERDER, of the same country, are considered, by many, as furnishing much new and important instruction on this subject.[x] And, finally, the numerous voyagers and travellers with which modern times have abounded, have contributed greatly to enlarge our knowledge of the human character and powers, and have brought to light many facts toward the formation of a satisfactory system on this subject.

In the natural history of *Quadrupeds*, the amount of improvement, during the last century, was very great. All the distinguished systematic writers before mentioned, have rendered extensive and

u *Plan of a Natural History of the Human Species delineated*, &c. 1796.

w *Essay on the Difference between the Conformation of the European and the Negro*, &c.

x MEINERS' work I have never seen, and am not well acquainted with its character; with that of HERDER I have some acquaintance, and am very far from believing that it merits the high character which many have given it.

important services to this branch of zoology. Besides these, the names of many other respectable naturalists might be recounted, who have devoted their investigations to particular species, and described them with great accuracy and splendour. The scientific journals and memoirs of learned societies, in every part of the century, exhibit a large and very interesting amount of labour performed by these diligent and useful inquirers.

But among the various investigations, in this department of natural history, which distinguish the eighteenth century, few are more curious than those respecting the *fossil bones of animals*, now no longer known in the living state. These remains of animals, chiefly of the quadruped kind, have been discovered at many different periods, from the commencement of the century to its conclusion; and in almost every part of the world, to which naturalists have had free access. Among many who have distinguished themselves by their inquiries respecting these *fossil bones*, are Sir HANS SLOANE, DAUBENTON, BUFFON, PALLAS,[y] GMELIN, and Dr. W. HUNTER. M. CUVIER, of France, has been for some time engaged in a very extensive work on this subject, which is likely to prove very interesting to the philosophical world. He

y Professor PALLAS expresses the fullest conviction, that the fossil bones found in *Siberia* were carried thither by the *Flood*, or by some such great inundation as the sacred history describes. His first idea was, that the climate was once warm enough to be the native country of the *elephant*, and that it had since undergone a radical change. But when he visited, during his travels, the spots where these bones were found, he candidly renounced his former hypothesis, and expressed a full conviction, in conformity with the opinion of many other modern philosophers, that they must have been carried thither by water; and that nothing but a sudden and general irruption of waters, such as the *deluge* is represented to have been, could have transported those bones, from their native regions, so far to the north. In proof of this he informs us, that the bones are generally found *separate*, as if scattered by the waves; covered with a stratum of *mud;* and commonly intermixed with the remains of *marine animals and plants*. *COXE's Travels in Russia.*

enumerates *twenty-three species* of bones which have been found, all belonging to animals unknown at the present day, and of whose existence there is no other trace than these relics. Of this number, *twelve* were determined by preceding inquirers, and *eleven* he considers as having been first discovered and settled by himself. Besides these, he speaks of a number of other species, concerning which some uncertainty still remains.

Of these *fossil bones* none have attracted more attention than those belonging to the unknown animal denominated the *Mammoth*,[z] found in several parts of the world, and especially in North-America. A controversy for a long time existed, whether this animal were a species of *elephant* or not; and both the affirmative and negative sides of the question were confidently maintained by eminent zoologists. It is probable the dispute is now near being terminated, as, in the estimation of good judges, proof little short of demonstrative has appeared, confirming the opinion of those who assign this far-famed animal to the genus *Elephas*.[a]

Soon after the first publications of LINNÆUS, *Ornithology*, or the history of the *second* class in his system, received considerable improvements from EDWARDS, an English naturalist, who, though not remarkably distinguished as a systematic writer, became eminent and useful by the accuracy of his descriptions, and the excellence of his drawings.

z The name *mammoth* is said to have been first given to this animal in *Russia*. It is a corruption from *memoth*, a word derived from the *Arabic*.

a In the year 1801 Mr. C. W. PEALE, of Philadelphia, proprietor of the *Museum* in that city, and who has been for a number of years distinguished by his taste for inquiries in natural history, succeeded in obtaining two complete skeletons of the *mammoth*, dug out of marle-pits, in the State of New-York. From an inspection of these skeletons it appears that they are the remains of *elephants*, differing but little, if any more, from either of the two species now known, than these latter do from each other. Mr. PEALE is certainly entitled to the thanks of every lover of natural history for his zeal and exertions in this research.

To his labours succeeded those of M. Frisch, a German, whose work is perhaps the most philosophical and interesting that was ever published on the subject. After him came the celebrated Latham, of Great-Britain, the author of a work on ornithology, which is probably the most extensive and complete yet presented to the world. The history of birds has also been well treated by Brisson and Buffon, of France; and those of *Africa* have been ably described by Vaillant, of the same country. In addition to which it may be worthy of notice, that the plates published by order of the King of France, and intended to accompany Buffon's history of birds, are certainly among the most elegant specimens of human art ever executed to promote the study of ornithology.

That department of zoology which includes the *Amphibia*, or the *third* Linnæan class, has also been greatly extended and improved during the eighteenth century. Besides Linnæus, this class was treated, with much ability, by Mr. Catesby, an English gentleman, who resided for some time in America.[b] Next to him, Dr. Garden, of Great-Britain, who spent a number of years in South-Carolina, communicated much new light with respect to the animals, generally, and especially the *Amphibia*, of our country.[c] Dr. Russell's great work on the *Serpents* of the Coromandel coast[d] is a production of the highest excellence in its kind, the publication of which was an im-

b *Natural History of Carolina, Florida, and the Bahama Islands*, &c. By Mark Catesby. 2 vols. folio.

c Dr. Garden, who was a respectable physician of Charleston, in South-Carolina, communicated to Linnæus much valuable information concerning the animals of America. Few names occur more frequently, or are mentioned with more honour in the *Systema Naturæ* than his.

d *An Account of Indian Serpents*, &c. By Patrick Russell, M.D. F.R.S. folio.

portant event in the progress of natural history. The *Serpents* have also been largely treated of by M. Lacepede, of France, who formed a new arrangement of them, founded chiefly on the scales, and bearing, in several respects, a considerable resemblance to that of Linnæus. The same writer has published a work on *Oviparous Quadrupeds*, in which he has much improved on the labours of the great Swedish naturalist. The natural history of the *Tortoise* has been very ably and completely executed by Schoepf, a distinguished writer of Germany. The *fascinating power* ascribed to *serpents* has been the subject of considerable discussion during the period under review. Those who have examined this subject in the most philosophical manner, are M. Lacepede, Professor Blumenbach, and especially Professor Barton, of Philadelphia, whose *Essay* on this subject is, perhaps, the most satisfactory hitherto presented to the student of natural history.

Within the same period, *Ichthyology*, or the history of the *fourth* Linnæan class, has been cultivated with equal diligence and success. In this branch of zoology, Artedi, a Swede, and fellow student of Linnæus, greatly distinguished himself. Next to him flourished Gouan, of Montpellier, who adopted the Linnæan arrangement, and did himself much honour by his writings on this subject. About the same time Marsigli, an Italian, in his history of the Danube, threw much light on the fishes of that river, and of course, on *ichthyology* in general. After Marsigli, M. Broussonett, of France, made a very instructive present to naturalists, in his work on the rare fishes, and those which had been before badly described. In the same high rank stands Professor Monro's celebrated work on the physiology of this class of animals. But of all the writers on this

department of zoology, BLOCH, a Jew physician of Berlin, is said to be the most able and complete. To which may be added, that LACEPEDE, before mentioned, has commenced the publication of an extensive work on fishes, of which great expectations are formed.[e]

The inquiries and discoveries in the *Insecta*, the *fifth* class in the Linnæan arrangement, have also been very great during the period in question. SWAMMERDAM was almost the only one who paid particular attention to insects before LINNÆUS. The latter, profiting by the labours of his predecessor, pursued his inquiries in this part of natural history with singular zeal and success. He discovered and described many new species, and greatly improved their arrangement. After LINNÆUS, appeared Madame MERIAN's *View of the Insects of Surinam*, a very splendid work, and a singular monument of female genius and perseverance. About the same time REAUMUR, of France, LYONET, of Holland, and BONNETT, of Geneva, greatly distinguished themselves by their respective publications in *Entomology*; and, though with different relative merits, decidedly improved upon all who had gone before them. In this department of zoology, also, within the period which we are considering, DRURY and DONAVAN, of England, GEOFFROY, of France, FABRICIUS, of Denmark, DE GEER, of Sweden, and, latest of all, OLIVIER, of France, have laboured with great diligence and success. With respect to the different degrees of honour due to these celebrated naturalists, it is not easy, within small limits, to state them with precise justice. The best judges seem to agree

[e] This great ichthyologist has already given four quarto volumes of his work to the public, containing a description of 309 Fishes, of which 54 were before unknown to naturalists. When finished it will probably be the most complete and splendid work on this branch of natural history in existence. GARNETT's *Annals of Philosophy* for 1800.

in assigning to REAUMUR and FABRICIUS the first rank.[f] The *insects without wings* have been very ably described by J. HERLET, of Germany. To these names may be added that of Dr. SMITH, the *Linnæus* of Great-Britain, whose account of the rarer *Lepidopterous Insects of Georgia*, is entitled to a place among the most splendid, accurate, and valuable zoological works of the age.[g]

In the investigation of the *Vermes*, the *sixth* and last class of LINNÆUS, the advances made in modern times have been no less distinguished. The first writer to be mentioned under this head is DONATI, whose work on the vermes of the *Adriatic* is considered highly instructive and important. After him Professor BOHADSCH, of Prague, laboured much to improve the history of this class of animals, and with brilliant success. BOHADSCH was followed by M. CUVIER, of France, who proposed a new arrangement, and rendered considerable service to this branch of zoology. The *human vermes* have been very ably treated by BLOCH, before mentioned. The vermes infesting the intestines of animals, generally, have been examined and described in a very satisfactory manner, by GOEZE, and SCHRANCK, of Germany. The discoveries of PEYSONNELLE, of France, with respect to *corals* and *corallines*, form one of the most interesting parts in the modern annals of natural history. *Corals*, at the beginning of the eighteenth century, were reckoned among the number of marine *plants*. In this rank they continued to stand until M. PEYSONNELLE, by a series of observations and experiments, from about the year 1720 to 1750, ascertained their *animal* nature. His doctrine was confirmed

f Of OLIVIER's work it is not easy to speak decidedly, as it is yet in an unfinished state.

g *The Natural History of the Rarer Lepidopterous Insects of Georgia*, &c. 2 vols. folio. 1798.

by the successive inquiries of TREMBLY, DONATI, B. DE JUSSIEU, and finally of the ingenious and accurate Mr. ELLIS, of Great-Britain, whose work on this genus of animal substances is certainly among the best extant.[h] On the fourth order of vermes, the *Zoophita*, Professor PALLAS, of Russia, has given to the public a most valuable work, of which the systematic arrangement, and philosophical accuracy, must ever recommend it to the discerning inquirer. The fifth order, or *Infusoria*, has been treated, with great successive improvements, by BONNETT, of Geneva, NEEDHAM, of Great-Britain, ADANSON, of France, and above all, by MULLER, of Denmark; the last of whom has investigated and exhibited this department of zoology in a manner more extensive, complete, and satisfactory than any of his predecessors.

Most of the naturalists above mentioned not only wrote with great ability on the several subjects connected with their names, but also made large additions to the facts and specimens known by preceding inquirers. Few of them failed to connect with the ingenuity of system a large mass of new and useful information. A considerable number of new *Quadrupeds* have been brought to light during the period of which we are speaking, and added to the old lists. The species of *Birds* arranged and described by LINNÆUS amounted to near a thousand. Since that time the number has been more than doubled, by the inquiries of the great ornithologists already mentioned; and also by the discoveries of Sir JOSEPH BANKS, MANDUIT, DESFONTAINES, DOMBEY, VAILLANT, and many others. The class *Amphibia*, though not so much extended, by the discovery of new genera and

h *Essay toward the Natural History of the Corallines, and other Marine Produstions of the like Kind.* 4to. 1775.

species, as some of the other classes, has yet received considerable augmentation in this way. Of *Fishes* LINNÆUS described about *four hundred* species; but since he wrote the catalogue has been so much enlarged by circumnavigators and travellers, that they now amount to considerably more than *one thousand.* The number of new species of *Insects* discovered at different periods of the century is prodigiously great. Before the time of LINNÆUS scarcely more than *two hundred* species were known. In the last editions of his works he described about *three thousand.* There are now known more than *twenty thousand* species. The same augmentation has taken place with respect to the *Vermes*, a class which, in the hands of ELLIS, PALLAS, MULLER, and others, before mentioned, has wonderfully enlarged its bounds.

Though our own country, during the period under review, has not produced many distinguished inquirers in zoology, it can boast of some who have rendered themselves conspicuous by pursuits of this nature. Mr. CATESBY, and Dr. GARDEN, before mentioned, though not native Americans, resided long in our country, and threw much light on the animal kingdom, as it appears on this side of the Atlantic. Mr. GLOVER, a planter of Virginia, also communicated to the public some valuable information respecting American zoology.[i] Mr. WILLIAM BARTRAM, of Pennsylvania, an indefatigable and well informed student of nature, added considerably to the number of facts before known concerning the animals of the southern and western parts of the United States, and the adjacent territory.[j] Still more recently Dr. BARTON,

i The principal part of Mr. GLOVER's communications respecting American zoology, appeared in the *Philosophical Transactions*, about the year 1740.

j *Travels through North and South-Carolina, Georgia, East and West-Florida*, &c. from 1773 to 1778.

Professor of Natural History in the University of Pennsylvania, has made very respectable additions to the zoological science of our country, and displayed a degree of genius, diligence, learning, and zeal, in this pursuit, which do honour to our rising Republic, and which bid fair to place him among the most accomplished and useful naturalists of his time.[k] Besides the labours of these and other scientific inquirers of America,[l] a large amount of information respecting the animals of our continent has been derived from intelligent foreigners, who have either visited and explored the interior of the country at different periods of the century under review, or devoted themselves to the acquisition of knowledge, from various sources, respecting the new world. Among these, GRONOVIUS, KALM, SCHOEPF, BUFFON, and several others, deserve to be mentioned with honour.

BOTANY.

In this branch of natural history the succession of discoveries and improvements which the period before us has displayed, is in the highest degree honourable to modern science. At the opening of the eighteenth century, Botanical Philosophy, though it had been long cultivated, was still in a

k See *Fragments of the Natural History of Pennsylvania*, *Essay on the Fascinating Power ascribed to Serpents*, &c. and several memoirs on particular articles in zoology in the *American Philosophical Transactions*.

l It would be easy to mention the names of many respectable American Gentlemen, who have done honour to themselves by giving new and valuable descriptions of particular animals which came under their observation. In such a list, Mr. JEFFERSON, Dr. MITCHILL, Rev. Mr. HECKEWELDER, and a number of others, would be entitled to distinction. To these might be added the names of the Rev. Drs. BELKNAP and WILLIAMS, who, in their respective Histories of *New-Hampshire* and *Vermont*, after the example of Mr. JEFFERSON, in his *Notes on Virginia*, have given valuable catalogues of the native animals of those States. But it is impossible for the author, consistently with the limits which he has prescribed to himself, to indulge the disposition which he feels to enter into such details.

very confused and imperfect state. Numerous had been the attempts to arrange the vegetable tribes into an intelligible system, but great disorder and deficiency appeared in every plan. Among these attempts the most respectable and successful were those of RAY and RIVINUS. The former, an English clergyman, before mentioned, had proposed his method to the world in 1682; but afterwards presented it in a new and improved form in 1700. He arranged all known vegetables under thirty-three classes, deriving the distinguishing character of each chiefly from the *fruit*. His system, though undoubtedly much superior to any which had been devised by his predecessors, was still very defective; and the characters of his plants were so many and various, as to create an intricacy in a high degree perplexing and painful to the student. To the method of RAY, succeeded that of RIVINUS, a Professor of Botany in the University of Leipsic. This learned man was the first who laid aside the distinction between herbs and trees, which had been universally adopted by those who went before him. Relinquishing also the pursuit of natural affinities, and convinced of the insufficiency of characteristic marks drawn principally from the fruit, he attached himself to the *flower*, as furnishing characters abundantly numerous, distinguishing and permanent. He reduced the number of the classes to eighteen, which were distinguished from each other by the *perfection* and *distribution* of the *flowers*, and particularly by the *regularity* and *number* of the *petals*. RIVINUS did not live to complete the publication of his system; the whole of which was finally laid before the world in 1711, by one of his disciples.

After the system of RIVINUS, the next worthy of attention is that of TOURNEFORT. This great

botanist set out with reviving the distinction of plants into herbs and trees, which had been exploded by RIVINUS. In his method there are twenty-two classes, and one hundred and twenty-two orders, denominated *sections*. The former founded on the regularity and figure of the *petals*, together with the situation of the *receptacle* of the flowers; the latter on the *pistillum* and *calyx*. Botanical writers generally speak of TOURNEFORT'S as the first regular and complete arrangement. He was certainly the first who ascertained and exhibited the *genera* of plants in a scientific manner; and, indeed, in general merit, as a systematic writer, he went far beyond all his predecessors. About the same time, Dr. HERMAN, Professor of Botany at Leyden, proposed a new system. He augmented the number of classes to twenty-five, founding their characters chiefly on the *fruit*. He divided his classes into eighty-two sections or orders, having for their basis the number of *petals*, *seeds*, *capsules*, and *cells*; the figure of the *seeds* and *petals*; and the disposition of the *flowers*. This system appears to have gained but little popularity. To the method of HERMAN succeeded that of Dr. BOERHAAVE, first published in 1710, and afterwards, with great additions, in 1720. He made a sort of combination of the system of RAY, TOURNEFORT, and HERMAN, with additions and improvements from his own great mind. He increased the number of classes still further, to thirty-four, which were subdivided into one hundred and four sections or orders; the characters of which were derived from the *habit* or general appearance of the plants, combined with all the parts of fructification. He was the first who employed the *stamina* and *style* in determining the genus. To this luminary of science, botany is much indebted. He introduced many new

genera into his system; and was universally considered as one of the most successful inquirers and instructive writers of his time, on this subject.

Next to the system of Boerhaave, the records of botany present us with the method of Christian Knaut, a German, who proposed what was afterwards styled, " the system of Rivinus inverted." This plan was published in 1716. It embraced seventeen classes, founded on the number of the *petals* alone; and one hundred and twenty-one orders, distinguished by the *fruit*. About the same time Christopher Knaut offered to the world a new system, which, in fact, was little more than an alteration of Ray's, without any substantial improvement. He was followed by Dr. Hales, before mentioned, whose celebrated work on " Vegetable Statics" threw much light upon the physiology of plants; and indeed entitles him to the honour of being considered the great father of this branch of botanical science. To Hales succeeded Micheli, an Italian, whose *Nova Genera Plantarum* must be ranked among the fundamental works of the age, as it doubtless formed an important step in the course of reformation and improvement. Contemporary with Knaut, was Magnol, a celebrated professor of botany at Montpellier, whose system was published in 1720. He divided the vegetable kingdom into fifteen classes, which derived their characters entirely from the *calyx;* and these, according to him, embraced fifty-five orders, whose distinguishing characters were taken from the *figure* of the *calyx*, *petals* and *seeds;* from the *disposition* of the *flowers;* from the *number* of *petals;* and from the *substance* of the *fruit*.

Such was the state of botanical philosophy until the year 1735—confused, intricate, unsettled, and exhibiting little but successive revolutions. And,

if all the systems of classification were vague, unsatisfactory, and perplexing, the language in use among the different instructors in this science was at least equally so. Almost every part of the different nomenclatures, at this time, was loaded with uncouth, erroneous, or supernumerary words, and even barbarous sentences of description, which exceedingly increased the difficulties of the learner. Besides, numerous voyagers and travellers were now constantly enriching botany with new treasures, brought from every quarter of the earth; and while the names of those before known already loaded the memory, it became necessary to provide new ones, for the successive discoveries which were daily demanding attention. In a word, so great was the number of new species presenting themselves from every direction, and such the perplexity arising from defective arrangement, that botany became in danger of relapsing again into anarchy and total disorder."[m]

In this stage of the science LINNÆUS appeared. Endued with genius and learning; having a taste for researches in natural history rising to a sublime enthusiasm; and a disposition for persevering industry, he cultivated, with particular diligence, the science of botany. In 1735 he published a new system, as the result of his labours, which produced a memorable æra in this branch of philosophy. This is usually called the *Sexual System*, from its foundation being laid in the doctrine, that plants are *male* and *female*, and propagate their species in a manner somewhat analagous to animals. LINNÆUS divided the whole vegetable kingdom into twenty-four classes; the distinguishing characters of which he founded on the *number*, the place of *insertion*, the *proportion*, the *connec-*

[m] See *Tracts on Natural History*, by JAMES E. SMITH, M.D. F.R.S.

tion, and the *disposition* of the *stamina*. These classes he subdivided into one hundred and twenty-eight orders. In the first thirteen classes, the orders are taken from the number and circumstances of the *pistilla*. In the fourteenth and fifteenth from the *pericarpium*; and in all the remaining classes from the number and circumstances of the *stamina*, excepting the twenty-fourth, which, from the parts of fructification being invisible, cannot be subjected to the grand principle of arrangement, on which the system proceeds.

With respect to the fundamental doctrine of the *sexes* of plants, on which this method of classification rests, the honour of originating it is said not to be due to the great Swedish naturalist. The ancients had some ideas of the doctrine, but they were vague and imperfect. We are informed by ARISTOTLE, that EMPEDOCLES particularly taught *that the sexes were united in plants*; and also that the use of the *farina fæcundans* of the male *palm*, in impregnating the female, was very well known in his day. It appears, also, from several passages in PLINY, that he, as well as other naturalists of that time, extended the distinction of sexes, and the use of the male dust, to plants in general. Accordingly, it is certain that the ancient cultivators perceived the necessity, and were in the constant habit, with respect to several species of vegetables, of promoting the operation of the male flower on the female, in order to the production of fruit; still, being inattentive to the structure of flowers, and ignorant of the offices belonging to the several parts, they remained unacquainted with the true process of nature, though it was daily open to their observation.[n]

[n] See DUTENS's *Origine*, &c. and PULTENEY's *Historical and Biographical Sketches of Botany in England*, 2 vols. 8vo. 1790.

Thus this celebrated doctrine rested in apparent forgetfulness, until 1676, when Dr. GREW, a distinguished botanist of England, who had been long employed in microscopical observations and experiments on plants, mentioned the fact, and suggested its importance, in a paper read before the Royal Society in the month of November of that year. He expressed an opinion that the *stamina* and *styli* of vegetables are analogous to the organs of generation in animals, and adapted by nature to answer the same purpose; and that the *pollen* probably emits certain *vivific effluvia*, which may produce impregnation. The *sexual* doctrine was further confirmed by the observations and experiments of CAMERARIUS, in 1695. In 1702, a small publication, by JOHN HENRY BURKHARD, a German physician, appeared in the form of an "Epistle to Leibnitz;" in which the author not only adopted the idea of the *sexes* of plants, but also suggested the possibility of forming an *arrangement* of vegetables according to the difference of the parts of generation.[o] A few years afterward, two botanists of France, GEOFFROY, in 1711, and VAILLANT, in 1718, declared themselves in favour of GREW's opinion; while TOURNEFORT and his friends opposed it with equal warmth.[p] In Great-

o About the year 1738, when the growing fame of LINNÆUS made him an object of envy among some of his contemporaries, Professor HEISTER, of Helmstadt, one of his antagonists, charged him with having taken his system, without acknowledgment, from the above mentioned work of BURKHARD. LINNÆUS, however, it appears, proved that he never saw this obscure performance; and even if he *had*, his friends contended, that it would have detracted little from his merit, that another had *slightly suggested* a plan which he so *ably executed*. See STOEVER's *Life of Linnæus*, translated by TRAPP. 4to. 1794.—Professor BARTON lately informed me, that he had seen a copy of BURKHARD's publication, in the *Loganian Library*, at Philadelphia, and that he considered the sexual doctrine as the foundation of botanical arrangement, as very distinctly suggested by the author.

p It is remarkable that the beautiful Latin *Poem* of M. DE LA CROIX, entitled *Connubia Florum*, of which the *sexual* doctrine forms the founda-

Britain, Blair, Bradley, Fairchild, and Miller, also appeared on the side of Grew's doctrine; but Alston, and some others, long retained their hostility against it with unabating zeal.

Such was the state of opinion with regard to this doctrine, when Linnæus adopted, unfolded, and made a splendid application of it to botanical science. And although we cannot ascribe to him the original discovery, yet he confirmed, extended, and improved it, and made it the basis of a system which has commanded greater admiration, and been more generally received than any before offered to the world. It will appear evident, on the slightest consideration of the subject, that the task of arrangement, in the vegetable kingdom, is a most perplexing and difficult one; and that every *artificial* classification must involve sacrifices of family resemblance, and natural connection. But the philosophers of every country seem to have yielded to Linnæus the praise of having formed a system, which, in facility, and universality, is superior to all hitherto proposed.

But it was not only in the *doctrines* and *arrangement* of botany, but also in the *nomenclature* of the science, that this distinguished natural historian excelled all his predecessors. He created a new

tion, was published as early as 1727. Some notice will be taken of this performance hereafter.

It is also worthy of notice, that James Logan, Esq. a learned and ingenious gentleman of Philadelphia, who was afterwards President of the Council, and Chief Justice of Pennsylvania, instituted a set of experiments on *maize*, with a particular view to the investigation of the *sexual* doctrine. An account of these experiments was first communicated in a letter to Peter Collinson, F. R. S. in 1735, and printed in the *Philosophical Transactions*, vol. xxxvi. This account was afterwards enlarged, and published in Latin, at Leyden, in 1739, under the title of *Experimenta et Meletemata, de Plantarum Generatione;* and republished with an English translation, by Dr. Fothergill, in 8vo. 1747. These experiments were considered and appealed to as among the most decisive in establishing the doctrine they were intended to illustrate and confirm. *Pulteney's Sketches*, &c. vol. ii. p. 278.

language, so simple, methodical, and convenient, that it has been pronounced likely to stand the test of ages, even if his sexual opinions should be discarded. In forming this language, he retained all the old names, which were consistent with his new principles; he adopted such others from the Greek and Latin, as were short, expressive, and sonorous; he dismissed the periphrastic and tedious descriptions of the former schools; he introduced *trivial names*, by which one, or at most two adjectives, distinguish a plant from all its other relative species;[q] in a word, he formed a language so simple and luminous, and so adjusted its several parts to his improved doctrines, that the acquisition of the science of botany became a far more easy task than before. In fact, this was so much the case, that, instead of remaining an abstruse study, confined to the schools, as formerly, it was converted into an agreeable amusement, to persons of leisure in all ranks and situations.

The new classification and nomenclature of LINNÆUS soon attracted general attention. At first, as might have been expected, they met with powerful opposition. When they first made their appearance in Great-Britain, SLOANE, DILLENIUS, and other English naturalists, opposed them with warmth. ALSTON, of Scotland, retaining his old prejudices, did the same; insomuch that the influence of the doctrines taught by RAY, threatened, for some time, to triumph over those delivered by LINNÆUS. This opposition, however, soon began

q The following will serve as a specimen of the convenience and utility of the *trivial names* invented and applied by LINNÆUS. A kind of *Grass*, before his time, was called *Gramen Xerampelinum, Miliacea, prætenuis ramosaque sparsa panicula, sive Xerampelino congener, arvense, æstivum; gramen minutissimo semine.* He gave it a name consisting of two words, *Poa bulbosa*, which designated the plant more distinctly and intelligibly than the long and perplexing description before used. STOEVER's *Life of Linnæus*, p. 201.

to decline. As the works of the illustrious philosopher of Upsal increased in number and circulation, the weight and superiority of his opinions were gradually manifested, until at length, the public adoption of the Linnæan system, by Professor MARTYN, of Cambridge, and Professor HOPE, of Edinburgh; the adaptation of RAY's *Flora Anglicana* to this arrangement, by HUDSON, about the year 1760; and, finally, the favourable reception given to the Swedish doctrines by the College of Physicians of London, completed the establishment of the *Sexual System* in Great-Britain.

The opposition to this system was no where stronger or more persevering than in France, where the authority of TOURNEFORT had long been so high and imposing; and where so many great botanists resided, each jealous for the honour of his country, and for the reputation of his own opinions. It is true, several of the naturalists of that country embraced the opinions of the illustrious Swede. Among these, SAUVAGES, GOUAN, GERARD, and LE MONIER, deserve to be particularly named. But by far the greater number became his adversaries, and those most distinguished by their learning and talents. The system which they opposed, however, gradually rose into importance, and extended its empire. Personal prejudices, and national jealousies were slowly yielded. And although it can by no means be said, even now, to be universally adopted, yet it is incomparably more popular than any other; and even those who reject some of the opinions which it involves, generally adopt its language as the most convenient and philosophical any where to be found.[r]

But the immediate achievements of LINNÆUS himself, in botanical philosophy, were not the

[r] PULTENEY's *Historical and Biographical Sketches of Botany*, &c.

only services which he rendered to this science. His researches and publications excited a general thirst for this kind of knowledge. From the school which he formed, many distinguished characters arose, who did honour to their instructor, and who greatly extended and improved his system. A number of these, incited by the zeal and the example of this patriarch in science, undertook distant voyages, and tedious and hazardous journies, for the sake of exploring such regions of the earth as were before unknown; and thus daily brought home new stores of knowledge from every quarter of the earth.

Since the publication of the *Sexual System*, several new methods of classification have been proposed, and still more numerous plans suggested for modifying and improving that of LINNÆUS. Among the most respectable of these may be mentioned the natural method of VAN ROYEN, Professor at Leyden, exhibited in his *Prodromus Floræ Leydenensis*, published in 1740, and which sustained a high character among botanists, for ingenuity and elegance. The next is that of Baron HALLER, one of the greatest men of the age in which he lived. He proposed, in 1742, a new natural system, founded on an assemblage of the various characters chosen by others. The botanical works of this philosopher rank in the very first class. He was a warm opponent of LINNÆUS, and sometimes, in this scientific warfare, departed from that mildness and urbanity which he owed both to himself and his adversary.[s] After HALLER, BERNARD DE JUSSIEU, of France, published a new method of classification, also a natural one. To him succeeded his countryman LA MARCK, the author of the botanical part of the *Encyclopædié*

[s] *Tracts on Natural History*, by JAMES EDWARD SMITH.

Methodique, who formed a new system. But although the works of the two last named writers are instructive and valuable, they are comparatively little known or followed out of their own country. In 1764 Professor GLEDITSCH, of Berlin, published a system, in some respects new, but differing so little from that of LINNÆUS, especially with respect to his ordinal distinctions, that it acquired but little celebrity.

About the year 1773, after vegetable physiology had been investigated for some time, and with great patience and ability, by HALES, BONNETT, and DU HAMEL, Sir JOHN HILL publi hed what has been commonly called his *Vegetable System*, in which he endeavours to class plants according to their *internal structure*. Though his ponderous work[ξ] conveys much instruction with respect to the physiology of plants, yet it has always been less esteemed in the author's own country than on the continent of Europe. In the same department of botanical science, the learned and accurate Professor WALKER, of Edinburgh, has done himself much honour, and furnished important aid to those who wish to investigate the structure of vegetables. The organs of plants, and the phenomena produced by their organization, have also been treated, with great ability, in a large work, by the Rev. M. SENNEBIER, of Geneva. Dr. GŒRTNER, a German botanist, has also given to the world a new system, founded on the *fruit*. His work, as it respects the *genera* of plants, may be considered one of the greatest and most classical that the eighteenth century produced. Professor THUNBERG, a Swede, who, by his researches in Africa and Asia, has rendered essential service to the science of botany, proposed, a few years ago, a

ξ Twenty-six volumes folio.

new modification of the Linnæan system, which, though ingenious, is of very doubtful utility. This modification has been since adopted by the indefatigable SWARTZ,[v] also of Sweden, who is so well known by his successful botanical inquiries in the West-India Islands. Besides these, new systems, or alterations in the Linnæan system, have been proposed by VAILLANT, SCHEUZER, LUDWIG, ALSTON, ADANSON, GMELIN, Sir WILLIAM JONES, and many other distinguished botanists. But time would fail in attempting to give a complete catalogue of the numerous writers, and projectors of reform, in this department of natural history. Perhaps in few branches of science have caprice and imagination displayed more extensive influence.

Dr. DARWIN, in his *Botanic Garden*, and his *Phytologia*, assuming the system of LINNÆUS, with some proposed alterations, exhibits great learning, genius, and taste. He carries further than any preceding botanist the idea of *plants being an inferior order of animals*, and ascribes to them *sensation, volition, passion, affection, virtue* and *vice.* Indeed, he pushes the doctrine to such an extravagant length, and founds upon it so many fanciful positions and reasonings, that the sober and wary inquirer must often be offended at the obvious triumph of a lawless fancy over the cautious spirit of philosophy.

The botanists who have inquired with diligence, or described with ability, in particular branches of this science, within the period under review, are too numerous to be recounted. The *Cryptogamia* have been ably treated by MICHELI, before mentioned, by HEDWIG, and by DICKSON and MASSON. The *Mosses* have been faithfully and successfully investigated by Professor DILLE-

v See his *Prodromus of West-India Plants.* Stockholm, 1788.

NIUS, of Oxford, by BRIDEL, of Gotha, by ZOEGA, of Denmark, and others. The *Lichens* have been examined and described with great care, by HAGEN and HOFFMAN, of Germany: the *Ferns* by MARATI, of Italy, by BALTON, of England, and by those above named, who have treated generally of the class to which they belong. The *Grasses* have been investigated and described by SCHEUCHZER, SCHREBER, CURTIS, and many more: the *Oaks* of North-America, by DU ROI, of Germany, and with unusual elegance by M. MICHAUX, of France: the *Ferula*, or *Assafætida-tree*, by Professor HOPE, of Edinburgh: the *Geranium*, by M. L'HERETIER, and the Abbe CAVENILLES:[u] the *Cotton-plant*, by VAN ROHR, of Denmark: the *Tea-tree*, by Dr. LETTSOM, of London: and the *Tobacco-plant*, by Mr. TATHAM, of England; besides a number of valuable descriptions, almost countless, of new and curious plants to be found in the memoirs of the *Linnæan Society* of Great-Britain, and other associations of a similar kind, in different parts of Europe. To these may be added, not as publications of the first class, but as doing honour to the infancy of botanical science in our country, the natural history of the *Persimmon-tree*, by Dr. WOODHOUSE; of the *Tobacco-plant*, by Dr. BRAILSFORD; of the *Phytolacca*, or *Poke*, by Dr. SCHULTZ; of the *Stramonium*, or *James-Town-weed*, by Dr. COOPER; and of the *Sumach*, by Dr. HORSEFIELD, all of the United States.

But besides these botanical writers, who have published useful accounts of particular classes, orders, genera, or species of plants, the last century has abounded beyond all former example with works on the plants of particular countries, or

u The work of this latter gentleman on the *Geranium* is very elegant. He has enumerated and described *one hundred and twenty-eight species.*

smaller districts. The plants of *Great-Britain* have been either collected, or ably described, during this period, by Dillenius, Alston, Miller, Blackstone, Hudson, Lightfoot, Robson, Curtis, Withering, Berkenhout, and Smith; those of *Ireland*, by Threlkeld, Keogh, and Smith; those of *France*, by Gouan, Gerard, Magnol, Adanson, Bulliard, Jussieu, and by several late botanists; those of *Switzerland*, by Haller; of *Holland*, by Commelin and Boerhaave; of *Germany*, by Crantz and Jacquin; of *Italy*, by Micheli and Allioni; of *Spain*, by the Abbe Cavenilles; of *Russia*, by Pallas; of *Denmark*, with great splendour, by Oeder, Muller, and their associates; of *Lapland*, by Linnæus; of *Siberia*, by Gmelin; of *Egypt* and *Palestine*, by Celsius, Hasselquist, and others; of *Amboyna*, by Rumphius; of *Ceylon*, by Burmann; of *Coromandel*, by Roxburgh; of *Japan* and the Cape of *Good-Hope*, by Kœmpfer and Thunberg; of the *Mauritius*, by Willemet; of *Cochin China*, by Loureiro; of *New-Holland*, by Smith; of the *West-India* Islands, by Sloane, Browne, Houston, Plumier, Jacquin, and Swartz; of particular parts of *North-America*, by Bannister,[w] Vernon, Kreig,[x] Catesby, Mitchell,[y] Garden, Gal-

w John Banister, an Englishman, who settled in *Virginia* toward the latter end of the seventeenth century, and devoted himself to the investigation of the plants of that part of America. He not only collected plants, but also described them, and himself drew the figures of the rare species. He became a victim to his favourite pursuit. In one of his excursions for collecting plants, he fell from the rocks and perished. His botanical friends did honour to his memory, by calling a plant, of the *decandrous* class, *Banisteria*.

x About the beginning of the eighteenth century, William Vernon, an Englishman, and David Kreig, a German physician, led by their genius for botany, made a voyage to *Maryland*, where they resided for a considerable time, and examined its vegetable productions. They returned to Europe, after having collected an *Herbarium* of several hundred new and undescribed plants.

y Dr. John Mitchell, an Englishman, who was sent to *Virginia*, in 1741, for the purpose of investigating the botanical treasures of America.

LISSONIERRE,[z] KALM,[a] CORNUTUS,[b] WANGENHEIM,[c] SCHOEPF,[c] and WALTER;[d] and by our respectable countrymen, CLAYTON,[e] BARTRAM,[f] COLDEN,[g] MUHLENBERG,[h] MARSHALL,[i] BARTON,[j] and CUT-

After having discovered many new genera and species, he returned to England, about the year 1748. He transmitted not only to his countrymen, but also to LINNÆUS, much valuable information respecting American plants. The great Swedish botanist viewed him with so much respect, that he took care to perpetuate his name, by giving it to an American plant, the *Mitchella Repens*.

z The Marquis DE LA GALLISSIONERRE, who, about the middle of the century, was Governor of Canada. He explored the natural history of that country with great industry, and returned to France laden with botanical riches.—KALM's *Travels*.

a A Swedish botanist, who was sent, in 1748, to America, for the purpose of discovering and collecting plants. After remaining between two and three years in our country, and collecting many new plants, in which pursuit he travelled through *Pennsylvania*, *New-Jersey*, *New-York*, and *Canada*, he returned to Sweden. See his *Travels*, translated by FORSTER, 2 vols. 8vo. 1772.

b *Canadens. Plant. Historia.*

c WANGENHEIM and SCHOEPF were two botanists who came to America, with the German troops, during the late revolutionary war. Their works on American plants, though by no means entitled to a place in the first class of botanical publications, are yet of considerable value.

d THOMAS WALTER, a planter of *South-Carolina*, who published, in 1788, *Flora Caroliniana*, a work of respectable character.

e Dr. CLAYTON, "a native and resident of *Virginia*. This accurate observer passed a long life in exploring and describing the plants of his country; and is supposed to have enlarged the botanical catalogue as much as any man who ever lived." *Notes on Virginia*. CLAYTON's *Flora Virginica* appears to have been first published about the year 1743. It was afterwards republished by GRONOVIUS, at Leyden, in 1762.—It holds a very important station in the history of botany.

f *Travels.*

g CADWALLADER COLDEN, Esq. Lieutenant-Governor of the Province of New-York, who was before mentioned. He had a great fondness for botanical studies. He made very valuable communications of American plants to LINNÆUS, especially those which appear under the title of *Plantæ Coldenhamenses*, in the *Acta Upsalensia*, for 1743 and 1744; and his name is mentioned frequently, and with great respect, in the *Species Plantarum* of that distinguished botanist. This gentleman's daughter, Miss COLDEN, was also fond of botany, and corresponded with LINNÆUS; who, in honour of one or both of them, in his *Flora Zeylanica*, gave to a plant of the *Tetrandrous* class, the name of *Coldenea*. STOEVER's *Life of Linnæus*, and PULTENEY's *Sketches*.

h *Index Floræ Lancastriensis.* Vols. iii. and iv. of the *Transactions of the American Philosophical Society*.

i *Arbustrum Americanum*, 8vo. 1785.

j *Collections for an Essay towards a Materia Medica* of the United States, and other publications. Dr. BARTON has also a larger work on botany now in the press, of which high expectations are formed.

LER;[k] and the plants of different portions of *South-America*, by PLUMIER, AUBLET, Mad. MERIAN, Don RUIZ, Don PAVON, and others; and of the *South-Sea Islands*, by the indefatigable Dr. FORSTER, whose *Nova Genera Plantarum* may be considered one of the most valuable additions made to botanical science since the time of LINNÆUS.

The catalogue of plants enumerated by the great botanist of Sweden last mentioned, amounted to about *ten thousand*. Of these he actually described about *eight thousand*. The number since discovered and added to the list is very great. Besides the numerous discoveries of new plants by some of the celebrated systematic writers before mentioned, M. COMMERSON, of France, in the course of his circumnavigation with BOUGAINVILLE, found near *fifteen hundred* new species. M. DOMBEY, of the same country, and Don MUTIS, of Spain, discovered a still greater number in South-America. M. DESFONTAINES brought to light near *four hundred* non-descripts, found in Africa. Dr. SIBTHORP brought *two hundred* new species from the Archipelago; Professor THUNBERG *six hundred* from Japan; M. SWARTZ more than *eight hundred* from the West-India Islands; and M. MICHAUX more than *four hundred* from the Levant, Persia, and North-America. To these may be added the several thousands brought from almost every quarter of the globe, by Sir HANS SLOANE, Messrs. LAGERSTROEM, OSBECK, TOREN, and DAHLBERG, Dr. SOLANDER, Dr. SPARMAN, Sir JOSEPH BANKS, Dr. FORSTER, and a long catalogue of modern circumnavigators and travellers, insomuch that the species now known and described considerably exceed *twenty thousand*.[l]

k *An Account of some of the Vegetable Productions naturally growing in America*, by MANASSEH CUTLER, D. D. *Memoirs of the American Academy of Arts and Sciences*, vol. i.

l See BERKENHOUT's *Synopsis of Natural History*, 2 vols. 12mo. 1789.

To the details above stated, it is proper to subjoin, that the eighteenth century has been productive, beyond all former precedent, of great elegance in the execution of *drawings* and *descriptions* of plants. These are too numerous, and too well known to render any particular account of them necessary here. It is sufficient to say, that all the means of communicating a knowledge of botany, whether we refer to the convenient nomenclature[m] now in use, to the modern concise and intelligible style of *description*, to the splendid representations of nature, by means of accurate *figures* and *coloured plates* which every where assist the student, or to the multiplication of *Botanic Gardens*,[n] and of *Herbaria*, as appendages to seats of science, they may be said to have reached a stage of improvement, within a few years, which the human mind never before contemplated. The recent exhibition of the Linnæan system by Dr.

m CONDORCET, in his Panegyric on LINNÆUS, expresses himself thus:—"LINNÆUS has been reproached with having rendered *too easy* the nomenclature of botany, and occasioned thereby the appearance of a great number of small works. This objection seems only to prove what progress botany has made under him. Nothing, perhaps, evinces better how far a science is advanced, than the facility of writing books of mediocrity on such a science, and the difficulty of composing works which contain novelty of matter." STOEVER's *Life of Linnæus*.

n Though *Botanic Gardens* have been greatly multiplied, during the last century, in Europe, by scientific individuals, and by seminaries of learning, our own country has never been able to boast of a single establishment which deserved the name. This deficiency is now likely to be in some measure supplied, so far as it respects the State of *New-York*, by the laudable zeal of Dr. DAVID HOSACK, Professor of Botany in Columbia College. This gentleman has lately purchased ground for a Botanic Garden, in the vicinity of the city of New-York; and is going on, at his own expense, to furnish it with the necessary stores of indigenous and exotic plants, for rendering it an useful and ornamental institution. It is to be hoped that his exertions will be seconded by public aid; and that the State of New-York, already eminently distinguished for its rapid progress in wealth and improvement, will not suffer the weight of supporting such an establishment to fall on an individual, who, after all his care to accomplish himself for this branch of instruction, in a foreign country, and his zeal in forming the best private botanical library in the United States, cannot be expected to devote all his resources to an object which ought to be fostered by public munificence, and cherished as one of the honours of the State.

THORNTON, of London, is not only highly honourable to himself and his country, but probably, also, in superb magnificence and accuracy, without an equal on earth.[o]

MINERALOGY.

This department of natural history has, also, within the period under review, passed through various revolutions, and received numerous improvements equally fundamental and important. From the time of ARISTOTLE, the first distinguished mineralogist, to that of BECHER, a learned German, little had been done in this science, except bringing together, and gradually increasing, a wilderness of facts, without system or order. BECHER, toward the latter end of the seventeenth century, turning his attention, with zeal, toward this subject, became the father of regular mineralogy. After him a number of adventurers in this field of inquiry appeared, but they did little more than make large collections of mineral substances, and class them according to the old rules. Among the principal of these were HIERNE, a Swede, who gave an ample and very valuable account of the fossils of his own country;—WOODWARD[p] and CHARLETON, English naturalists, who made curious collections and enumerations of mineral specimens;—and BRACHMEL, of Sweden. who threw much new light on this kingdom of nature, as it appeared in that part of Europe. To these succeeded LINNÆUS. This great man proposed a new classification of mineral bodies, and was the first who distri-

o This is the opinion of Dr. DARWIN, whose taste or information on this subject will not be questioned. *Phytologia.*

p WOODWARD instituted a professorship of mineralogy about the year 1720, in the University of Cambridge, to which he left his collection of minerals as a legacy.

buted them into *classes*, *orders*, *genera*, and *species*. But his arrangement was essentially defective. He divided substances chiefly according to their external appearances, such as *figure*, *colour*, *hardness*, and other sensible qualities, and, of course, threw together the most heterogeneous and opposite kinds. He devised specific names, however, of great excellence; and he is entitled to much honour for his concise and elegant sketch of the *Saxa*, which had been little noticed before.

Linnæus was followed by his countryman, Wallerius, who, in 1747, published an important mineralogical work, in which he adopted the Linnæan system, with considerable alterations and improvements, by himself and the learned Browal, Bishop of Abo.[q] About the same time Vaugel, a respectable philosopher of Germany, presented to the public a new system of mineralogy, of considerable value. In 1748 appeared the voluminous work of Dr. Hill, which was important, as it gave a general account of the fossils of England; but his perplexed and barbarous nomenclature rendered it much less useful than it might otherwise have been. Soon afterwards the inquirers and publications in mineralogy began greatly to multiply, especially in Germany and Sweden, which, from the abundance of their mineral riches, have long presented peculiar encouragements to the study of this kingdom of nature.

Hitherto little or nothing had been done in the investigation of minerals through the medium of *chemical analysis*. External characters continued to form almost the sole ground of distinction and arrangement. Hierne and Brachmel had, indeed, some time before, suggested the plan of form-

q See the Preface to Cronstedt's *Mineralogy*, by Magellan. The above mentioned work of Wallerius was republished, about twenty-five years afterwards, with great and splendid improvements.

ing a mineralogical system on chemical principles; but they did nothing more than suggest it. MARGRAAF and POTT, two illustrious mineralogists of Berlin, seem to have been the first who instituted, with any remarkable success, this kind of inquiry. Their numerous and well directed experiments were generally made by means of *heat*, and, according to the language of chemistry, in the *dry way*. About the same time, NEUMANN, a philosopher of Germany, distinguished himself by investigating the nature of mineral substances by means of acid *menstrua*, or in the *moist way*. These inquiries opened a new and most interesting field in this science, led to many important discoveries, and may be considered as one of the grand æras in natural history.

It was in this stage of mineralogical improvement that FREDERIC CRONSTEDT, a nobleman of Sweden, and superintendant of the mines of that country, published a most incomparable work, exhibiting the elements of this science, in an arrangement singularly clear, determinate and perspicuous.[r] This distinguished mineralogist assumed Mr. POTT's facts, but improved much upon his labours. He adopted a method of classification chiefly chemical. He appears to have derived a considerable portion of his knowledge from VAN SWAB, one of the masters of the mines, whose name is little known in the scientific world, though he communicated much information to almost all the eminent naturalists of that country, who flourished during his time.

Though POTT and MARGRAAF did much in the chemical analysis of minerals, and shed new light

r WALLERIUS pronounced this work *opus sine pari*. It has passed through many editions; has been translated into most of the European languages; and is still considered as one of the best elementary works on mineralogy extant.

on the science by this means, yet they left much still to be done. They were followed by SCHEELE, and BERGMAN,[s] who, with great ingenuity, perseverance, and success, pursued the same course. In the hands of these great philosophers, mineralogy may be said to have first assumed that high rank which it now holds. They not only made large additions to the lists of mineral substances which had been before given, but they also pursued the analysis of these substances to a greater length than their predecessors, ascertained new and more clear distinctions, and gave the whole science a more simple, intelligible, and dignified aspect. As long as this branch of natural history shall be cultivated, a large share of gratitude and admiration will be due from its votaries to SCHEELE and BERGMAN.

Though the refinements of chemical analysis were carried to a great length by the celebrated mineralogists last mentioned, and entitle them to high honours, yet they were afterwards exceeded by KLAPROTH, of Berlin, who applied himself to the analysis of minerals with a degree of zeal and perseverance which no difficulties could discourage, and with an ingenuity and accuracy which enabled him to penetrate far beyond his predecessors. He corrected many errors, and supplied important defects in the analytic method. He invented new instruments of great value, and new processes, more easy and expeditious, and of more certain result than those before in use. It is, perhaps, to his labours, as much as to those of any individual, that we are indebted for some of the most curious knowledge in mineralogy that we possess. The same course of refined and subtle chemical investigation, by which KLAPROTH was

s *Sciagraphia Mineralis.*

so much distinguished, was pursued farther by succeeding chemists, and particularly by M. Vauquelin, of France.

While this astonishing progress was making in mineralogy, by means of chemical inquiry, the attention to *external characters*, which had been for some time out of vogue, began to be resumed, and led to considerable improvements in the diagnostic rules, and in the nomenclature of the science. For this we are chiefly indebted to the celebrated Werner, of Germany, who certainly holds a place among the most distinguished mineralogists of the age. Though he did not wholly neglect the chemical properties of fossils, he devoted his chief attention to their *external characters*, and made these the principal foundation of his arrangement. He and his disciples insisted, that the *colour*, *shape*, *lustre*, *transparency*, *texture*, *cohesion*, *density*, *feel*, and general *habitude* of mineral substances, furnish abundantly sufficient indications for distinguishing and arranging them. And, indeed, the ingenuity and skill with which they selected these characters, the judgment and accuracy with which they learned to apply them, and their wonderful success in forming a luminous system on the principles which these sensible qualities afforded, must be considered as pointing out one of the most important periods in the history of mineralogy.

Before this period the *nomenclature* of mineral bodies had been in a very perplexed and imperfect state, insomuch, that while rich stores of knowledge respecting them were possessed by many, it was extremely difficult to convey this knowledge, for want of precise definitions and descriptions. The same substance, from some slight variations in appearance, was often called by different names; and different substances, from some affinities of external character, by the same name.

From these, and other causes, the language of mineralogy was long arbitrary, vague, and ambiguous; each author using that which his caprice, or his convenience dictated. Many attempts were made to supply this defect, and to obviate these difficulties, by LINNÆUS, PEITHNER, and others, but without much effect. At length WERNER undertook to make a radical reform in the descriptive language of this science, and published the result of his labours in 1774. This nomenclature proved more precise, accurate, and scientific than mineralogists had ever before possessed; and its illustrious author, by afterwards uniting the descriptions of external characters, which he had formed with much taste and skill, with terms indicating the chemical properties of minerals, was enabled to publish, in 1780, the best system of mineralogical language that is now extant.[t]

Since the publication of WERNER's system, almost all the distinguished writers on mineralogy have formed their arrangement and language on the *union* of *external characters* and *chemical properties*. This is the case with the learned and indefatigable Dr. WALKER, of Edinburgh, Messrs. DAUBENTON, PATRIN, and MONGE, of France, and Mr. KIRWAN, of Ireland. All these gentlemen have inquired much, and written with ability, on this branch of natural history. The last named philosopher, in particular, has rendered very important services to mineralogical science, and, doubtless, deserves to be ranked among the greatest of its benefactors now living.[v]

Besides the systematic writers just mentioned, several naturalists, of great eminence, have founded

t This latter publication was in the form of *Notes on* CRONSTEDT's *Mineralogy.*

v See *Elements of Mineralogy.* By RICHARD KIRWAN, F. R. S. &c. 2 vols. 8vo. 1794.

mineralogical distinctions on characters peculiar to themselves, and have pursued their inquiries, founded on these characters, to a very curious and instructive length. ROME DE LISLE, of France, in his *Crystallographie*, published a few years since, made a very ingenious application of *geometry* to the phenomena of minerals, and exhibited a work in which they were subjected to all the precise principles of mathematical calculation. Since the publication of DE LISLE's work, his countryman, M. HAUY, has given a new theory of *crystallization*, in which mathematical skill and persevering industry are still more eminently displayed than by his predecessor. This theory is acknowledged by all to be a monument of ingenuity and labour; and is supposed by some to give important light, and to promise much usefulness, both in mineralogy and chemistry. M. BRISSON, another distinguished mineralogist, of the same country, proposed to found the leading character of mineral bodies on the *static principle*, or their relative *specific gravities*; and in the exhibition of his plan displayed much ingenuity and learning. Scarcely inferior to any that have been mentioned is the venerable M. SAGE, also of France, who, in the art of *assaying*, in tracing the connection between the mineral and the other kingdoms of nature, and by his experiments in chemical analysis, has contributed much to improve this department of natural history.

In addition to the great systematic writers whose names have been mentioned, considerable service has been rendered to mineralogy, within the period under consideration, by many others, who have either collected, analyzed, or discovered mineral productions. Among these it is proper to enumerate, with some distinction, LAWSON, TOWNSON, JAMESON, WHITEHURST, LEWIS, AN-

DERSON, WITHERING, and GARNET, of Great-Britain; D'ARGENVILLE, SOULAVIE, FAUJAS, MACQUART, DOLOMIEU, MONNET, CHAPTAL, BOMARE, FOURCROY, HASSENFRATZ, and DE LA METHERIE, of France; LUDWIG, WOLTERSDORFF, CARTHEUSER, Baron BORN, DEBERN, VOIGT, GELLERT, WOULFE, RASPE, and many more, of Germany; DE SAUSSURE, jun. of Geneva; RINMAN, and FERBER, of Sweden; PALLAS, of Russia; D'ACOSTA, of Spain; CAMERA, of Portugal; and GIOENNI, FABRONI, and SPALLANZANI, of Italy.

The use of the *Blow-Pipe*, for the purpose of assaying mineral bodies in the *dry way*, was first introduced by VAN SWAB, a little before the middle of the century. The importance of this apparatus in mineralogy, and the great ease with which it enables the experimenter to conduct his investigations, render its introduction by no means an inconsiderable æra in the history of the science. After VAN SWAB, the *Blow-Pipe* was much improved, and more extensively applied, by CRONSTEDT, BERGMAN, RINMAN, BERKENHOUT, BLACK, and several others. The great value of this invention, in chemical and mineralogical inquiries, will appear from considering that the most intense degree of heat may be obtained by it, with the utmost conveniency, in a few minutes, which can scarcely be obtained by means of a crucible in many hours.

While new systems of arrangement, and of language in mineralogy, and new means of facilitating experiments in this science have been proposed, by different philosophers, during the period under review, immense additions, at the same time, have been made to the old catalogues of mineral substances. LINNÆUS described about *five hundred* different species. Since that time so many discoveries of new substances have been

made, that the number of species now known is between *seven* and *eight thousand*. Seven new kinds of *earth* have been discovered within the century under consideration. Among these are *Magnesia*, by HOFFMAN and BLACK; *Barytes*, by SCHEELE and GAHN; *Strontites*, by HOPE; *Silica*, by POTT; *Alumina*, by MARGRAAF;[n] *Adamanta*, by KLAPROTH; and *Jargonia*, by the same great mineralogist. Within this time, also, *ten* new *metallic* substances have been discovered, viz. *Cobalt*, by BRANDT, in 1733; *Nickel*, by CRONSTEDT, in 1751; *Platina*, by SCHEFFER, in 1752; *Manganese*, by SCHEELE and GAHN, in 1774; *Tungsten*, or *Wolfram*, by D'ELHUYART, in 1782; *Molybdenum*, by HIELM, about the same year; *Uranium*, by KLAPROTH, in 1789; *Titanium*, by the same philosopher, in 1795; *Tellurium*, or *Sylvanite*, also by the same, in 1797; and *Chromum*, by VAUQUELIN, in 1798.—Besides these, the discoveries belonging to almost every class, order, and genus in mineralogy, have been more numerous than our limits admit of recounting.

It follows, as a natural consequence, from what has been stated, that *collections of minerals* have been more numerous, and more complete, during the last century, than ever before. Among those who have formed these collections, it is not easy to select such as are most worthy of notice. In general, the great systematic writers, whose names have been mentioned, are entitled to the highest praise in this respect also. The best collection now on earth, if we may rely on the judgment of Mr. KIRWAN, from which few will presume to dissent, is that made between the years 1782 and 1787,

[n] It is not meant to be asserted that *siliceous* and *argillaceous* earths were unknown previous to the time of POTT and MARGRAAF, but that the discovery of their characters and properties, as *pure* earths, is to be attributed to these mineralogists.

by Professor LESKE, of Leipsic, one of the earliest and most eminent of the disciples of WERNER, by whose assistance it was arranged. After the death of LESKE, it was revised, corrected, and enlarged by KARSTEN, another disciple of WERNER, and a mineralogist of great judgment and learning. This monument of skill and labour was, a few years since, transferred to Ireland, where it has been for some time receiving those additions and improvements from the hands of Mr. KIRWAN, which his extensive acquaintance with the subject, together with his acuteness, zeal, and industry, render him so capable of conferring.

In describing the present state of mineralogical science, it is impossible to do better than to adopt the words of the illustrious Irish academician, whose name has been mentioned with so much respect in the preceding paragraphs. Within a few years, "precise lines of information have been traced, even in the minuter subdivisions of the science; the gross indications of the unassisted senses, freed from their attendant fallacies, have been pressed into its service; the more refined chemical tests, still further perfected, have been rendered more conclusive, many new species brought to light, the catalogue of the elementary substances nearly completed, and the great art of analysis, extended far beyond its former limits, now nearly approaches the precision of an algebraic formula."[w]

This science, like almost every other cultivated in modern times, while its boundaries have been extended, and its principles greatly improved, has been rendered more subservient than formerly to various important purposes of economy and art. Instead of being considered, as it once was, a low

w KIRWAN's *Elements of Mineralogy. Preface.*

and trifling object of study, it has lately begun to be viewed as dignified in its nature, and most interesting in its relations. It is now regarded as a valuable and indeed necessary handmaid to *Medicine*, *Agriculture*, and a large portion of the *manufactures*, which supply the conveniences, comforts, or luxuries of human life. Mineralogy has, therefore, within a few years past, been cultivated with great diligence and success by almost all the nations in Europe, especially in *Germany* and *Sweden*, where splendid mineral riches particularly invited inquiry and application. Societies have been formed for extending and improving the science; travellers have explored foreign countries for the same purpose; distinguished eminence in this branch of knowledge has been rewarded by public esteem, and by civil honours; and the most effectual methods used to direct general attention to the subject.

The mineral treasures of our own country have been hitherto but little explored. It were to be wished that some of our countrymen, who have leisure and talents for the purpose, might be induced to undertake this interesting task. That the United States abound in *Coal*, *Gypsum*, *Marble*, *Metals*, and other mineral riches, which would abundantly reward the diligence of our naturalists in seeking for them, we have already had satisfactory evidence. Professor MITCHILL was commissioned, several years since, by the Agricultural Society of New-York, to travel through a considerable part of the State, with a particular view to mineralogical investigation. The result of his tour has been published,[x] and affords at once honourable testimony of his talents, and strong in-

x See a *Sketch of the Mineralogical History of the State of New-York* in the *Medical Repository*, vols. i. and iii.

citements to a further prosecution of the inquiries which he instituted. It would be happy for the interests of science in this new world, if similar undertakings, conducted with similar skill, could be multiplied and extended.—It is, indeed, devoutly to be wished that a kind Providence may for ever conceal from our view all mines of the *precious metals*, if there be such in our country; but so many mines of more real value to a nation have been discovered, and profitably wrought within the last age, in the United States, that we may safely wish for the extension, and the more diligent improvement of these discoveries.

Geology.

In the investigation of the natural history of the *Earth*, little progress had been made prior to the commencement of the eighteenth century. Indeed, as Mineralogy is the alphabet, by the principles and combinations of which the great volume of geological science must be formed, it is plain that as long as the former remained in an uncultivated state, the latter would receive but little light or improvement. During the century under consideration, geology has become an object of the attention and inquiries of many distinguished philosophers. The discoveries of chemists and mineralogists, and the observations of intelligent travellers, have all tended to facilitate these inquiries, and to render them more enlightened and satisfactory. And, although modern times have produced many visionary theories, and crude conjectures on this subject, they have also given birth to some important acquisitions, and much correct philosophy, which will be highly prized by all who study the history and structure of our globe.

Toward the close of the seventeenth century, *three* different *Theories of the Earth* were proposed, by as many philosophers of Great-Britain; of which, as they were among the first offered to the world, and bear a relation to several of the subsequent theories, it will be proper to take some notice.

The first was the *Telluris Theoria Sacra*,[y] of the Rev. Dr. THOMAS BURNET. This celebrated theorist was a man of genius and taste; and his work, if it do not command the assent of the philosophic mind, will be found to display much learning, and a most vigorous imagination. According to him the earth was first a fluid heterogeneous mass. The heaviest parts descended and formed a solid body. The waters took their station round this body, and all lighter fluids rose above the water. Thus, between the coat of air, and that of water, a coat of oily matter was interposed. But as the air was then full of impurities, and contained great quantities of earthy particles, these gradually subsided, and rested upon the stratum of oil, and composed a crust of earth, mixed with oleaginous matter. This crust was the first inhabitable part of the earth; and was level and uniform, without mountains, seas, or other inequalities. In this state it remained about sixteen centuries, when the heat of the sun gradually drying the crust, produced, at first, superficial fissures or cracks; but in process of time, these fissures became deeper, and increased so much in their dimensions, that at last they entirely penetrated the crust. Immediately the whole crust split in pieces, and fell into the abyss of waters which it had formerly surrounded. This wonderful event was

y This work was first published in 1680, in the Latin language. It was afterwards translated, by the author, and published in two parts, in 4to. in 1683, and 1690.

the universal *Deluge.* These masses of indurated earthy and oily matter, in falling into the abyss, carried along with them vast quantities of air, by the force of which they dashed against each other, accumulated, and divided in so irregular a manner, that great cavities, filled with air, were left between them. The waters gradually opened passages into these cavities, and in proportion as the cavities were filled with water, parts of the crust began to discover themselves in the most elevated places. At last the waters appeared no where but in those extensive valleys which contain the ocean. Thus our ocean is a part of the ancient abyss; the rest of it remains in the internal cavities, with which the sea has still a communication. Islands and rocks are the small fragments, and continents the large masses of the antediluvian crust. And as the rupture and fall of the mass were sudden and confused, the present surface of the earth is full of corresponding confusion and irregularity.[z]

This "elegant romance" of BURNET was succeeded by the work of his countryman, Mr. WOODWARD, who, in 1695, published *Essays towards a Natural History of the Earth*, and terrestrial bodies. Though he possessed much more knowledge of minerals than his predecessor, and on this account had greatly the advantage of him, he produced a work far less ingenious and interesting. He also proceeded on the supposition of the Mosaic history being true, and ascribed the present aspect of our globe to the influence of the general deluge. He supposed that all the substances of which the earth is composed were once in a state of solution; that this solution took place at the flood; that on the gradual retiring of

z SULLIVAN's *View of Nature*, vol. i. letter 6.

the waters the various substances held in solution, or suspended in them, subsided in distinct strata, according to their specific gravities; and that these are arranged horizontally, one over the other, like the coats of an onion. As this theory was soon found to contradict some of the plainest and most unquestionable facts which geologists observed, it has had few admirers, and its refutation has been usually considered as obvious and easy.

In 1696 Mr. WILLIAM WHISTON, a man of uncommon acuteness, and of still greater learning, published a *New Theory of the Earth*, from its original to the consummation of all things. He supposed the earth, in the beginning, to be an uninhabitable *Comet*, subject to such alternate extremes of heat and cold, that its matter, being sometimes liquefied, and sometimes frozen, was in the form of a *chaos*, or an abyss surrounded with utter darkness. This chaos was the atmosphere of the comet, composed of heterogeneous materials, having its centre occupied with a globular, hot, solid nucleus, of about two thousand leagues diameter. Such was the condition of the earth before the period described by Moses as the time of *creation*. The first day of the creation every material in this rude mass began to be arranged according to its specific gravity. The heavy fluids sunk down, and left to the earthy, watery, and aërial substances, the superior regions. Round the solid nucleus is placed the heavy fluid, which descended first, and formed the great abyss upon which the earth floats, as a cork upon quicksilver. The great abyss is formed of two concentric circles; the interior being the heavy fluid, and the superior water; upon which last, the earth, or the crust we inhabit, is immediately formed. So that, according to this theorist, the globe is composed of a number of coats or shells, one within the

other, of different materials, and of different densities. The air, the lightest substance of all, surrounds the outer coat, and the rays of the sun, making their way through the atmosphere, produced the light which *Moses* tells us first obeyed the divine command. The hills and valleys are formed by the mass of which they consist pressing with greater or less weight upon the outer coat of the earth; those parts which are heaviest sinking lowest into the subjacent fluid, and making *valleys*, and those which are lightest, rising higher and forming *mountains*.

Such Mr. Whiston supposed to be the state of the globe we inhabit before the *Deluge*. Owing to the superior heat, at that time, of the central parts, which have been ever since cooling, the earth was more fruitful and populous anterior to that event than since. The greater vigour of the genial principle was more friendly to animal and vegetable life. But as all the advantages of plenty and longevity which this circumstance produced, were productive only of moral evil, it pleased God to testify his displeasure against sin, by bringing a flood upon a guilty world. The flood was produced, as this theorist supposed, in the following manner. A *Comet*, descending in the plane of the ecliptic to its perihelion, made a near approach to the earth. The approximation of so large a body, raised such a strong tide, and produced such powerful commotion in the abyss concealed under the external crust, that the latter was broken, and the waters which had been before pent up, burst forth with great violence, and were the principal means of producing the deluge. In aid of this, he had recourse to another supposition, which was, that the comet, while it passed so near the earth as to produce these effects by the force of attraction, also involved our globe in its atmos-

phere and tail for a considerable time, and deposited vast quantities of vapours on its surface, which produced violent and long continued rains; and, finally, that this vast body of waters was removed by a mighty wind, which dried up a large portion, and forced the rest into the abyss from which it had been drawn, leaving only enough to form the ocean and rivers which we now behold.

The fanciful and untenable theories which have been briefly stated, served little other purpose than to amuse the curious, and excite to new, and, for the most part, unsuccessful modes of speculation on this interesting branch of natural history. Accordingly, the eighteenth century has teemed with plans, almost numberless, for solving the phenomena, and elucidating the internal structure and history of the earth. These plans, to say nothing of the impious nature and tendency of some of them, have, generally, rather resembled philosophical dreams, than the conceptions of waking and sober reason. Their authors, in forming them, have been too often guided by imagination more than judgment; and have laboured rather to support a favourite hypothesis, than to consult the voice of authentic history, or patiently to examine the materials and structure of the fabric which they undertook to describe. It may not be improper to take a brief review of some of the more conspicuous, among the great number, which, at different periods of the century under consideration, and in different parts of the world, have been received by philosophers.

At an early period of the century, the celebrated John Hutchinson, whose principles of philosophy were mentioned in a former chapter, formed a theory of the earth, which he professed to derive

from Scripture.[a] He supposed that when the earth was first created, the terrestrial matter was entirely dissolved in the aqueous, forming a thick, muddy, chaotic mass; that the figure of this mass was spherical, and on the outside of this sphere lay a body of gross dark air; that within the sphere of earth and water was an immense cavity, called by Moses the deep; that this internal cavity was filled with air of a kind similar to that on the outside; that on the creation of light the internal air received elasticity sufficient to force its way through the external covering; that immediately on this, the water descended, filled up the void, and left the earth in a form similar to that which it bears at present; that when it pleased God to destroy mankind by a flood, he caused, by his own miraculous agency, such a pressure of the atmosphere on the surface of the earth, that a large portion of it was forced into the internal cavity which it had formerly occupied, and expelled the waters from thence with great violence, spreading them over the surface; that the shell of the earth was, by this means, utterly dissolved, and reduced to its original state of fluidity; and that, after the divine purposes were answered by the deluge, the globe, by a process similar to that which at first took place, was restored to the form which it now bears.

In the year 1740 the Abbe Moro, of Italy, published a theory of the earth, which he chiefly derived from the works of Ray, of the preceding century. He supposed that the surface of the earth, as we now behold it, and especially the mountainous parts, arose, originally, from the bottom of the ocean. At first, according to him,

[a] This theory was enlarged and commented upon by Mr. Catcot, a follower of Hutchinson, who, in 1768, published a volume on the subject.

these mountains contained neither strata of shells, nor any organized fossils; but by means of subterranean conflagrations, earthquakes, and volcanoes, these substances were thrown up, in confused heaps, after which they successively subsided according to their different specific gravities, and thereby necessarily disposed themselves in different strata. He also maintained that these submarine eruptions, while they threw up huge and irregular masses of matter, also ingulphed marine plants and animals of every kind, which subsided in like manner, and thus formed new mountains, and new beds of stones, sand, metals, and other minerals, intermingled with the remains of vegetable and animal bodies, all which remained under the sea till some new agitation threw them above its surface. He supposed that the waters by which the earth was originally overflown subsided by degrees, the dry land first appearing in places adjacent to that where the first man and animals were placed at the creation; that the land extended itself gradually, a considerable time elapsing before the waters had returned into their proper bed, during which time the shell-fish, multiplying in great abundance, were universally distributed by the waters of the sea; and that when the bottom of the ocean was raised up by the earthquakes that accompanied the deluge, and formed the mountains, whole beds of such shells were thrown up, and distributed as we now behold them.

About the year 1744 M. Le Cat, a philosopher of France, proposed a theory of the earth differing from all which had preceded it. According to him, in the beginning, the substance whence metals, stones, earths, and other mineral bodies were to be formed, was a soft mass, consisting of a kind of mud. The earth was a globe, or regular spheroid, and its surface was uniform

and free from hills and valleys. The sun and moon were afterwards created. The fluid which covered the mud became agitated by the flux and reflux, to which it was subjected by attraction, and the mud was variously and violently moved. This agitation increasing, part of the mud became exposed, and dried. Continents were thus formed. The materials of the earth being compact and solid, the sea continually excavated its bed; and from the continual retreat of the sea, and the excavation of the earth, this globe is doomed to be at last so perfectly undermined as to produce a confluence of the sea from hemisphere to hemisphere. The earth becoming thus hollow, and its shell being gradually extenuated, will, at length, fall to pieces; a new chaos will be formed; the fabric will be again revived, as at first; and a periodical dissolution and renovation will take place. —Le Cat professed to believe the sacred scriptures, and discovered an anxious desire to show that his theory was consistent with them; but the best judges among his contemporaries, and since that period, have pronounced it equally inconsistent with the structure and phenomena of our globe, and with the Mosaic history.

About the year 1750 appeared the *Telliamed* of M. Maillet, a French writer of some note. He taught, that the earth was once wholly covered with water, which, by means of strong currents, raised in its bosom all those mountains which different countries bear on their surface; that this water has been ever since gradually diminishing, and will continue to diminish until it shall be quite absorbed; that our globe, being then set on fire, will become a sun, and have various planets revolving in its vortex, till its igneous particles being consumed, it will be extinguished; that then it will roll through the immensity of space, without

any regular motion, till it is again covered with watery particles, collected from other planets, when it will fix in the vortex of a new sun, and again go through the same course of motions and changes, being supplied with fresh inhabitants, resembling those by which it is tenanted at present; that the earth has probably been undergoing revolutions of this kind from all eternity, and will continue to go through a succession of them without end.—This atheistical and absurd theory, if it deserve the name, not more hostile to revelation than to all sound philosophy, seems to have gained but few adherents, and but little celebrity.

After M. MAILLET, his countryman, the Count DE BUFFON, formed a new theory of the earth, which has been much celebrated, and, notwithstanding its inconsistency with revelation, and the visionary absurdities which it involves, has gained many advocates and admirers.—According to this ingenious theorist, a comet falling into the body of the sun with great force, struck from its surface a large mass of liquid fire. The comet communicated to this fragment thus driven off from the sun, a violent impulsive force, which it still retains. This fragment forms the globe we inhabit. It assumed its present figure when in a fluid state. As the heated mass gradually cooled, the vapours which surrounded it condensed, fell down in the form of water upon the surface, depositing at the same time a slimy substance, mixed with sulphur and salts, part of which was carried by the waters into the perpendicular fissures of the strata, and produced metals; the rest remaining on the surface, and giving rise to vegetable mould, with more or less of animal and vegetable particles. Thus the interior parts of the globe were originally composed of vitrified matter, and they continue so at present. Above these were placed those bodies

which the fire had reduced to the smallest particles, as sands, which are only portions of glass, and above these pumice stones, and the dross of melted matter, which gave rise to different clays. The whole was covered with water to the depth of five hundred, or six hundred feet. This water deposited a stratum of mud, mixed with all those materials which are capable of being sublimed or exhaled by fire, and the air was formed of the most subtle vapours, which, from their levity, rose above the waters.

Such was the condition of the earth, as BUFFON supposes, when the tides, the winds, and the heat of the sun began to introduce changes on its surface. The diurnal motion of the earth, and that of the tides, elevated the waters in the equatorial regions, and necessarily transported thither great quantities of slime, clay, and sand; and by thus elevating these parts of the earth, sunk those under the poles about two leagues. The great inequalities of the globe took place when it assumed its form and consistence; swellings and blisters arising, as in the case of a block of glass or melted matter. In the act of cooling it became furrowed, and variously irregular. The vitrescent matter of which the rock of the globe is composed, and all the nuclei of mountains were produced by the primitive fire. The waters have only formed the accessory strata, which surround the nuclei horizontally, and in which are the relics of shells, and other productions of the ocean. The whole surface of the earth, therefore, as we now behold it, was, at a period long subsequent to its separation from the sun, covered by an ocean; and the waters forming this ocean probably remained for a succession of ages on what are now inhabited continents. Hence the remains of marine plants and animals to be found in almost every part of

the globe, on or near its surface. M. BUFFON supposes, further, that since the period when the primitive waters encircled the earth, there have been repeated partial inundations, in different places, and in others instances of land, formerly covered with the ocean, being elevated above it, and becoming inhabitable; and similar events, he seems to suppose, may in future occur. According to him, also, the earth, for many ages, too intensely heated to admit the existence of animal life on its surface, first acquired at the poles a more genial temperature. There, consequently, must we look for the first abodes of man. To *Greenland* or *Iceland*, to *Spitzenbergen* or *Nova-Zembla*, we must have recourse for the verdant bowers of Eden. And, finally, he contends, that all the other planets belonging to our system were stricken off from the sun in the same manner with that which we inhabit, and have probably undergone similar changes, so far as their respective circumstances admitted.

Such are the outlines of a theory bold and plausible, as might have been expected from the mind of its author, but unsubstantial and deceptive. Its manifest object is to exclude the agency of a Divine Architect, and to represent a world begun and perfected merely by the operation of natural, undesigning causes. That it cannot be reconciled with the sacred history, will appear evident on the slightest inspection; and that it involves the grossest philosophical absurdities has been clearly shown by succeeding geologists. It was embraced, however, by M. BAILLY, of France, by the celebrated HOLLMAN, of Goettingen, and others; and continues to be respected and adopted by many to the present time.

M. DE BUFFON's theory was warmly opposed, soon after its publication, by RASPE, a geologist of

Germany.[b] He also opposed the theory of MORO, before mentioned, though he considered it as approaching much nearer the truth than the ingenious fable of the French naturalist. He insisted, that the opinion of continents and mountains having been thrown up from the bottom of the ocean, solely by submarine conflagrations and volcanoes, was abundantly refuted by close observation. He contended, likewise, that in veins of sand, marble, chalk, and slate, there are found no indications of a burning soil, but rather of a sediment disposed by the agitation of the sea. Accordingly, he maintained, that the strata of which the shell or surface of the earth is composed, were originally formed at the bottom of the sea, by the constant agitation of the waters, and the continual production of plants and shells; that the subterraneous explosions and earthquakes, breaking through the bottom of the sea, not only formed banks, hills, and submarine mountains, of its broken parts, but also frequently raised up such large portions of the bed of the ocean, with its incumbent strata, as to form islands and dry mountains. At some times, as he supposed, the presence of so large a body of water caused it to break through the cavities made by previous eruptions, and, at other times the violence of the subterraneous explosions was so great as to remove mountains from one place to another; while the heat of the internal fires causing these explosions was so intense as to melt, calcine, or vitrify all adjacent substances.

In 1773 Dr. WILLIAM WORTHINGTON, of Great-Britain, published a theory,[c] in which great learning and piety, and a considerable share of ingenuity are combined. He maintained that the

b *Specimen Historiæ Naturalis Globi Terraquei.—Autore* RUDOLPHO ERICO RASPE, 8vo. Leipsic, 1763.

c *Scripture Theory of the Earth*, 8vo. 1773.

earth, in its primitive state, was plain and uniform; that all mountains, and every thing irregular and rugged in the surface of it, are the result of the curse pronounced on the ground after the fall; that the melancholy lapse of our first parents was immediately followed by earthquakes, and every species of convulsion, which produced these dreadful effects in the surface of our earth; that the antediluvian earth greatly abounded with water, much more than at present, and that the greatest quantity of it was collected about the poles; that at first the poles of the earth were erect, and at right angles with the plane of the equator; that the centre of the earth was then the centre of gravity; that the deluge was produced by the centre of gravity being removed twenty-three degrees and an half nearer to one of the poles, which led to a corresponding deviation of the poles from their former position, and thus threw the great body of water accumulated round them on those parts of the earth where little had existed before, and by these means drowned them. This event, he supposed, increased the irregularity of the earth's surface, and produced many of those phenomena, which so plainly establish the reality of the general deluge.

Another British theorist, of still more celebrated name, published a new system of geology in 1778. This was Mr. WHITEHURST, a gentleman of respectable talents and information, and whose theory has attracted considerable attention.[d] Mr. WHITEHURST supposes, that not only this globe, but the whole of the planetary system was once in a state of fluidity, and that the earth acquired its oblate spheroidical form by revolving round its axis in that state. In this fluid state, the component

d *An Inquiry into the Original State and Formation of the Earth*, &c. by JOHN WHITEHURST, F. R. S. 1778.

parts of the earth were suspended in one general undivided mass, "without form and void." These parts were endued with a variety of principles or laws of elective attractions, though equally and universally governed by the same law of gravitation. They were heterogeneous; and by their attraction progressively formed a habitable world. As the component parts of the chaos successively separated, the sea universally prevailed over the earth; and this would have continued to be the case had it not been for the sun and moon, which were coeval with the earth, and by their attractive influence interfered with the regular subsiding of the solid matter, which was going on. As the separation of the solids and fluids increased, the former were moved from place to place, without regularity; and hence the sea became unequally deep. These inequalities daily becoming greater, in process of time dry land was formed, and divided the sea; islands gradually appeared, like sand banks above the water, and at length became firm, dry, and fit for the reception of the animal and vegetable kingdoms. He supposed that mountains and continents were not primary productions of nature, but of a very distant period from the creation; that they are the effects of subterranean fires and commotions, and were produced when the strata of the earth had acquired their greatest degree of firmness and cohesion, and when the testaceous matter had assumed a stony hardness. And, finally, that the *marine shells* found in various places, on and below the surface of the earth, were, for the most part, generated, lived, and died in the places in which they are found; that they were not brought from distant regions as some have supposed; and, consequently, that these beds of shells, &c. were originally the bottom of the ocean.

Two or three years after the appearance of Mr. Whitehurst's publication, M. De Luc, of Geneva, dissatisfied with all the numerous theories which had been proposed, offered another, which has occupied considerable attention in the scientific world.[e] He supposes that the ocean once covered our continents; that the bottom of the old ocean was full of mountains, which neither the waters, nor any other cause known to us, formed, and which he therefore calls *primordial.* These mountains rose above the surface of the waters, and formed islands. These islands, and the ancient continents, were fruitful and well peopled, and the ancient sea had tides, currents, and tempests, as the present ocean. These powers acting upon the soft matters which are known to have formed the bottom of the ancient ocean, produced accumulations of calcareous substances, which, in process of time, became more or less mixed with marine bodies. The rivers, in the mean while, carried from the land into the sea scattered remains of animal and vegetable productions; the sea itself washed them from its coasts into its bosom; and these materials, transported by currents, became a secondary soil upon its primordial bottom. Fires and elastic fluids, formed by fermentations, made various openings in the bottom of the ocean, whence proceeded torrents of liquid substances and lava, which gave rise to the volcanic mountains observable on the surface of our continents. The continents which existed in a state of population and fertility, while the sea covered those which we now inhabit, though they did not form a solid mass, but were, properly

[e] *Lettres Physiques, et Morales, sur l'Histoire de la Terre, et de l'Homme,* &c. by J. A. De Luc, 8vo. 5 tom. 1780. This theory, as to its principal outlines, was first suggested by Mr. Edward King; but was afterwards much extended and improved by M. De Luc.

speaking, vaults, which covered immense caverns, maintained their elevation above the level of the ocean by the strength of their pillars, which, being of primordial matter, were solid and stable. But the changes which the subterranean fires produced at the bottom of the ancient sea, opened passages for its waters into the interior of the earth; the fermentation produced by this irruption shook the pillars of the primitive earth, which, sinking into its caverns, the old continents disappeared, and their surface descending below the level of the waters, a general inundation ensued. This was the general deluge. The sea now covered all the globe, except the islands of its ancient bottom, which increased in number and magnitude, until the weight of the water added to that of the superior vaults, crushed the inferior ones, and deepened more and more the new bed of the ocean; so that, at last, by a motion rapid, but not violent, all the waters retired from their former bed, and left our continents dry. Secondary mountains, and other irregularities were afterwards formed by volcanic commotions, and maritime currents and convulsions.

This learned and ingenious theorist professes a firm belief in revelation, and insists that all the principal lines in the Mosaic history are confirmed, and none of them contradicted by the most attentive survey of the globe. It may well be questioned, however, whether some parts of his theory can be reconciled with the sacred records; and they are precisely those parts which it is most difficult to reconcile with reason and sound philosophy.

Next to the theory of M. De Luc appears that of Mr. Miln, of Great-Britain, which, though less celebrated, is by no means unworthy of notice.[f]

[f] *A Course of Physico-Theological Lectures on the State of the World, from the Creation to the Deluge*, by Robert Miln, A. M. 8vo. 1786.

This gentleman declares himself a warm friend to revelation, and professes to have formed a system in strict conformity with the sacred history. In some respects he agrees with Mr. WHITEHURST; in others, he adopts the opinions of M. DE LUC; while, with regard to a third class of his doctrines, he claims to be original. He supposes that the earth, immediately after the fall, and in consequence of the divine curse pronounced against it, underwent a total change, by means of the elementary fire lodged, at that time, near its centre; and that hence arose the irregularities which now appear in the earth's surface.

The theory of MILN was followed by that of Dr. JAMES HUTTON, of Edinburgh, which has been much more distinguished, and excited incomparably more attention. Dr. HUTTON thinks[g] that all our rocks and strata have been formed by subsidence under the waters of a former ocean, from the decay of a former earth, carried down to the sea by land floods; that the strata at the bottom of the ocean were brought into fusion by subterraneous fires, and consolidated by subsequent congelation; that these strata were forced up, and made to form islands and continents by similar agency; that the shells, and other exuviæ of animals, gradually collected and incorporated with these strata, make about a fourth part of our solid ground; and that the foregoing operations, viz. the waste of old land, the formation of new under the ocean, and the elevation of the strata now forming there, into future dry land, are a progressive work of nature, which always did, and always will go on, forming world after world in perpetual suc-

g *Theory of the Earth; or, an Investigation of the Laws observable in the Composition, Dissolution and Restoration of Land upon the Earth*, by JAMES HUTTON, M. D. F. R. S. E. This memoir is contained in the *Transactions of the Royal Society of Edinburgh*, vol. i.

cession. Consequently, according to this theory, the continents which we now inhabit must, in process of time, be worn away and destroyed, and others be forced up to supply their place. The length of time to be allowed for this successive destruction and reproduction, Dr. HUTTON supposes to be far greater than is generally imagined. His system, therefore, is to be arranged, of course, among those which are hostile to the sacred history; and the best judges have pronounced it equally hostile to the principles of probability, to the results of the ablest observations on the mineral kingdom, and to the dictates of rational philosophy.

It has been suggested, that this doctrine of the *igniform* origin of our globe appears to be drawn from the theory of M. BUFFON, with the difference of perpetually renovating powers, having no determinate commencement, instead of a once slowly forming, and now gradually decaying principle. Dr. HUTTON, indeed, does not attribute the fusion of terrestrial substances to the state in which this planet issued from the sun, but to subterraneous fires and furnaces, coeval with it, and still existing undiminished.[h]

In 1790 appeared a new theory of the earth, by Mr. JOHN WILLIAMS, an English mineralogist, of respectable character, which, though it has not acquired much celebrity, is entitled to a transient notice in the present sketch.[i]

Mr. WILLIAMS supposes, that the superficial parts of the earth were originally mixed with water into a fluid or chaotic mass. All the regular strata were formed by the flow of the tides successively spreading out the deposited matters on a

h HOWARD'S *Thoughts on the Globe*, &c.

i *Natural History of the Mineral Kingdom*, &c. by JOHN WILLIAMS, 2 vols. 8vo. 1790.

large horizontal plane. The granites, and other stones, which he does not consider as stratified, subsided when the water was in some degree of rest, as at the highest of the tides, or where local obstructions produced stagnation. When the whole surface was in a fluid state, the tides necessarily rose to a prodigious height, several miles higher than the tops of any of our mountains. The mountains of granite, which are uniform throughout, must have subsided in one tide. The tides were highest, and had their resting places on the two opposite parts of the globe, which are now the continents; and their direction, on different parts of the globe, was such as we now find that of the strata to be. He maintained, further, that the interior body of the earth was formed in the same manner, prior to the superficial parts. From various causes it was full of inequalities. It contained much water, both in the composition of the not yet consolidated strata, and in separate cavities; so that when the superficial strata were laid between the tides, and the ocean began to retreat into its present bed, the weight of these superincumbent strata forced out the water imprisoned below them. These strata themselves, as yet soft and flexible, were, in many cases, bent and broken; cracks were occasioned by their contraction in drying, which cracks were increased by the inclination of the strata, in different ways, and were widest at the top; and the whole solid matter diminishing in bulk, as it became dry, high tides still overflowed it, and poured extraneous stony matter into the fissures. On these principles he explains all the declivities, ruptures, interruptions, and irregularities which we now behold. The larger grains and fragments found in the composition of our rocks, and all those bodies which are of a similar structure, and not crystallized, were once in dis-

tinct strata, though not now to be found in that state. This he considers as one of the many evidences which our earth every where affords of the general deluge. By the high tides, and violent agitation of the diluvian waters, the primitive strata, which had never before felt any rain, were loosened, torn asunder, and ground down by attrition against each other, and all the superficial parts of the earth reduced again to a chaos. When the waters began to abate, the larger stony particles and fragments subsided first, and formed the compound rocks, and beds of sand; and the finer and lighter sediment was spread, by the tides, into strata of different consistency.

The next theory entitled to notice is that of M. DELAMETHERIE, of France, which has been, of late, very fashionable in that country, and produced considerable discussion among naturalists.[j] He supposes that the external crust of our globe was formed in the bosom of the waters, from which it emerged in a state not very different from its present appearance. The crust, after its formation, underwent a variety of small alterations, from local causes. The waters surpassed the highest mountains; in other words, they were at least three thousand toises above their present level. All mountains, vallies and plains, were formed by *crystallization* amidst the waters. The materials which formed them were truly dissolved; but, as they would require much more water of solution than is now to be found, it is evident that most of the waters of the primitive seas have disappeared. These, he thinks, have chiefly retreated into the bowels of the earth; that cavities were formed there at the time of the crystallization of

j *Theorie de la Terre*, 8vo. 5 tom. Paris. 1797. This large work embraces much extraneous matter. The fourth and fifth volumes contain the author's theory.

the globe, which were at first filled with elastic fluids; but the water afterwards finding its way into them, became lodged there; that some caverns have been formed by subterraneous fires; but that the most powerful cause of them has been the refrigeration of our globe; and that, though the surface of the earth has been brought to its present state by the action of water, it may, at the first moment of its formation, have undergone a very great degree of heat, as happens to a comet passing near the sun.

In the formation of this theory, M. DELAMETHERIE discovered considerable ingenuity, and great learning. He can scarcely, however, be called an original writer. VOIGHT had held the doctrine of the aqueous *crystallization* of strata before him; and, indeed, the greater part of his system is made up of parts collected from different theorists. This is generally considered as one of those theories which are hostile to revelation.

Of a very different character is the theory of Mr. HOWARD, a British geologist, who, about the same time, published his opinions on this subject.[k] This gentleman is a firm believer in revelation, and his theory is intended to be perfectly consistent with the sacred history.

He supposes that the elements of all material substances were originally in a confused mass, called the abyss, without motion or animation; and that the present order of things was gradually, and at different intervals, drawn from it by means of laws impressed by the power of the Creator. The earth, of which we now behold the ruins, was originally constructed with its poles perpendicular to the equator; the centre of gravity was the cen-

k *Thoughts on the Structure of the Globe, and the Scriptural History of the Earth, and of Mankind,* &c. by PHILIP HOWARD, Esq. 4to. London, 1797.

tre of the globe; and the year consisted of three hundred and sixty days. At that time, the irregularities of the earth's surface being less considerable, and the distribution of land and sea being more equal, the atmosphere was more temperate and salubrious, and, of course, the life of man was prolonged greatly beyond its present limits. The termination of this "golden age" might have been effected by the proximity of a *Comet*, condensing the vapours of the atmosphere, and attracting the subterraneous waters, which, bursting through the exterior surface, precipitated indiscriminate portions of the primitive earth into the cavities below. The more perfect consolidation of the globe in the southern hemisphere changed the centre of gravity, which produced a proportionate deviation from the plane of the equator. The ocean did not, at once, however, sink to its present level. The posterior accession of waters from seas hitherto inland, may have crushed down other inferior vaults, and finally settled its lowest degradations. As the land became thus elevated above the bed of the ocean, the cold became more intense, the vicissitudes of climate were more severely felt, and the life of man suffered a proportionate abbreviation.

Mr. HOWARD was succeeded by M. P. BERTRAND, of France, who next proposed a theory, much less philosophical, and in every respect unworthy of a sober mind.[l] This wild and impious theorist contends, that water was the original substance of our earth, but that this water, before motion and heat were communicated to it, was a solid mass of ice. Such was the condition of the globe we inhabit, when one of the larger order of comets, after long wandering about, finally ended its career, and fulfilled its destination by striking

[l] *Nouveaux Principes de Geologie.* Par P. BERTRAND, &c. 8vo. Paris, 1798.

this frozen mass, breaking it in pieces, and mixing its own materials with those of the till then lethargic body. These fragments acquired by this impulsion a common projectile motion, in the same plane, and in the same direction. The light, heat, and life brought by this energetic comet, mixing with the original ice, formed new combinations, afforded causes of internal motion, and began, by these means, a new order of things, which M. BERTRAND calls vital and organic constitution, and which he supposes to be different in every planet, since the density is different. The ice, by means of heat, as a solvent, being reduced to primordial matter, all ancient combinations were destroyed, and room was given for new combinations of a different kind. The first result of this regeneration was the production of calcareous earth, from which species every other kind of earth is formed. This deposition of calcareous matter being equal every where, produced a regular nucleus in our globe, equally covered with water, and free from valleys and mountains. In this situation, according to our theorist, a new comet of high degree approached near enough to our globe to influence its destinies; by the force of its attraction it changed and slackened both the annual and diurnal motions of the planet, displaced the axis and the equator, altered likewise the points at which the spheroid was compressed or elevated, and by these means displacing the waters, caused the emersion of the first continents. The surfaces of these continents became unequal, from the change of level, and from the sudden retreat of the waters. The whole mass, however, was yet composed of calcareous matter. The first action of atmospherical powers, and of solar rays, occasioned a sudden irruption of all the vital forces, so long suspended and concentered. In this ex-

plosion of life every particle of native soil was *vivified*, and numerous races of vegetables and animals were produced, in such numbers and of such sizes, that putrefaction and fermentation ensued. Some meteoric phenomena having set fire to this monstrous heap of putrefied bodies, the horrid conflagration extended every where, even under the sea, and was the cause of most tremendous earthquakes, which broke all the strata, which, till then, had been horizontal, and threw them in every direction. The ashes of this almost universal conflagration being the most saline of the then existing substances, formed a *lixivium*, which, filtering through the interstices of the broken strata, produced the *quartz*, and other similar substances which now compose them. Wherever this lixivial and quartzeous flux deposed large quantities of matter, *granite* was formed; and by a different modification of the same materials, other mineral bodies were composed. This great conflagration occasioned hollows and cavities of incalculable dimensions, which being laid open by some violent shock, were filled by waters of the ocean, by which sudden retreat of the watery element, large portions of the globe were left dry, and formed new continents, while parts of the old continents fell into hollows, and disappeared. Besides our earth, which has undergone this series of revolutions, an indefinite number of like cold lifeless masses exist, resting invisible in darkness and inactivity, waiting for some favourable circumstance, which may bring them to light, life, and motion.

Such are the outlines of a theory, which, though exhibited and defended with some talents, may be considered as the most wild, and as involving the most palpable opposition to every received principle, that has yet been presented to the public,

Indeed, its unreasonableness and extravagance are so great, that it seems to have attracted but little respectful attention among any class of philosophers.

This theorist was succeeded by another, of the same name, but a much more sober and rational inquirer. In 1799 M. L. BERTRAND, of Geneva, published a work[m] which was intended to account for the phenomena of the globe we inhabit. This gentleman supposes, with Dr. HALLEY, that there is a magnetic nucleus enclosed and suspended in a hollow space, in the centre of the earth. This has a rotatory motion of its own, and an inclination of its magnetic axis to the axis of rotation, thus causing an oscillatory motion in the magnetic poles. While things were in this situation, he supposes that a *Comet* of ordinary size and character approached our earth, displaced the nucleus from the centre, removed it toward one side, and changed the centre of gravity of the earth. These circumstances occasioned the derangement of the seas, their removal to other parts of the globe, the immersion of old, and the emersion of new continents. This theorist is a disciple of M. DE SAUSSURE,[n] and the principal design of his work seems to have been to show the possibility of that sudden retreat of the ocean which his master believed in and taught, and to account for that event, and the subsequent elevation of the land which before formed its bottom.

The last person to be mentioned, as having adventured in this ample field of speculation and

[m] *Renouvellemens Periodiques*, &c. Par L. BERTRAND, &c. 8vo. 1799.

[n] M. DE SAUSSURE had promised to give a geological system, at the end of his *Travels* over the *Alps*; but after many years, he contented himself with informing the public, that the result of his investigations induced him to believe, that the whole of our continents had been formed under the sea, had been arranged by its action, and were left dry by a precipitate retreat of its waters.

inquiry, is Mr. KIRWAN, whose name has been so frequently, and so respectfully mentioned in the foregoing pages. This gentleman, with that learning which has enabled him to prosecute his numerous investigations in so enlightened a manner; with that judgment and penetration which render his inquiries so valuable; and with that spirit of patient and accurate observation which is so indispensably necessary to a successful developement of this subject, has framed a theory of the earth, which is perhaps the most rational and probable extant.[o]

Mr. KIRWAN believes, that the superficial parts of the globe were originally in a soft liquid state, proceeding from solution in water, heated at least to 33°. and possibly much higher; that this menstruum held in solution all the different earths, the metallic, the semi-metallic, the saline, and the inflammable substances; that in this fluid its solid contents coalesced and crystallized, according to the laws of elective attraction; that these were deposited in strata according to the predominant proportion of the ingredients; that by this crystallization of these immense masses a prodigious quantity of heat must have been generated, and increased by the decomposition of the water, intercepted in the precipitated ferruginous particles, and by the disengagement of inflammable air, even to incandescence, the oxygen uniting with the inflammable air, and bursting into flame; that this stupendous conflagration must have rent and split, to an unknown extent, the solid basis on which the chaotic fluid rested; that from the heated chaotic fluid must have been extricated the *oxygen* and *mephitic* airs, which gradually formed the atmos-

o *Geological Essays*, by RICHARD KIRWAN, Esq. F.R.S. &c. &c. 8vo. 1799.

phere; that from the union of oxygen with ignited carbon, proceeded the *carbonic acid*, the absorption of which, as the chaotic fluid cooled, occasioned the crystallization and deposition of *calcareous earth.* Mr. KIRWAN also believes, that the immense masses thus crystallized and deposited, formed the primitive *mountains;* that the formation of *plains* took place from the subsequent deposition in the intervals of distant mountains, of matters less disposed to crystallize; that the level of the ocean gradually subsided, leaving large and elevated tracts of land uncovered; that the *creation of fish* was subsequent to the emersion of the land; that after this retreat of the sea, the earth soon became covered with vegetables, and peopled with animals, being in every respect fitted to receive them; that the gradual retreat of the waters continued until a few centuries before the general deluge; that this event was occasioned by a miraculous effusion of water both from the clouds and from the great abyss, the latter originating in and proceeding from the great southern ocean below the equator, and thence rushing on to the northern hemisphere, spreading over the arctic region, and descending again southward; that during this elemental conflict, the carbonic and bituminous matter ran into masses no longer suspensible in water, and formed *strata of coal;* and that other substances, by the combination or decomposition of their respective materials, formed various other kinds of mineral bodies, as *basaltic masses*, *calcedonies*, *spars*, &c.

Besides the *Theories* of which an attempt has been made to give a brief view, many others, less distinguished, have been offered to the world, during the period under review. Among these it would be improper to pass in silence the geological systems of SCHEUCHZER, PLUCHE, ENGEL, LULOLFF,

PYE,[p] WALLERIUS,[q] BAILLY, FRANKLIN,[r] DARWIN,[s] and several others no less eminent. Some of these gentlemen have adopted theories, nearly agreeing in their outlines with several of those which have been stated; and to attempt a further detail of such as have any considerable claims to originality, would be to present the reader with new vagaries of imagination, rather than with sober inquiries of philosophy.

But although there has been, in modern times, as appears from the foregoing pages, a wonderful variety of fanciful productions, under the name of geological theories, we are by no means to imagine that little has been usefully done in this department of natural history. Amidst all the splendid rubbish with which it has been incumbered, some precious treasures have been brought to light. Amidst the speculations which have *darkened counsel*, large additions have been made to our knowledge of this important subject. These may be briefly summed up in the following particulars.

The *materials* for the formation of a correct and rational theory of the earth have been greatly augmented during the last age. Enlightened mineralogists, practical miners, and patient chemical experimenters, have been engaged, throughout the century, in making accurate observations; in visiting foreign countries; in exploring the bowels of the earth; in comparing the strata of every portion of the globe; in examining their form, direction, extension, and connection; in analyzing their component parts; and in collecting a multitude of facts, which have all tended to throw light on the

p *The Mosaic Theory of the Solar System*, by SAMUEL PYE, M. D. 4to. 1765.

q *Meditationes Physico-chemicæ de Origine Mundi.* 8vo. Stockholm, 1779.

r *Conjectures concerning the Formation of the Earth*, in a letter to the Abbe SOULAVIE. See *Americ. Philos. Trans.* vol. iii.

s See the *Botanic Garden: Additional Notes* to part i.

origin and history of our planet. By means of the useful discoveries which these inquirers made, we have been furnished with weapons for beating down false theories, and with information enabling us to pursue our investigations further, and with more advantage. "In this magnificent display of the internal arrangement of the globe," says Mr. KIRWAN, many philosophical observers acquired distinguished eminence from tedious, laborious, painful, but successful exertions. TILAS, GMELIN, CRONSTEDT, FERBER, PALLAS, CHARPENTIER, BORN, WERNER, ARDUINO, DE LUC, SAUSSURE, and DOLOMIEU, are names consecrated to immortality.[t]

"So numerous, indeed," says the same respectable writer, "have been the more modern geological researches, that since the obscuration or obliteration of the primitive traditions, strange as it may appear, no period has occurred so favourable to the illustration of the original state of the globe, as the present, though so far removed from it. At no period has its surface been traversed in so many different directions, or its shape and extent, under its different modifications of earth and water, been so nearly ascertained, and the relative density of the whole so accurately determined, its solid constituent parts so exactly distinguished, their mutual relation, both as to position and composition, so clearly traced, or pursued to such considerable depths, as within these last twenty-five years. Neither have the testimonies that relate to it been ever so critically examined and carefully weighed, nor, consequently, so well understood, as within the latter half of the past century.[v]

t *Geological Essays. Preface.* It is a curious fact, that while some of these celebrated inquirers embraced geological principles unfriendly to revelation, they have all brought to light facts, and given views of the subject, which remarkably confirm the sacred history.

v *Geological Essays*, p. 3, 4.

Difficulties have been lately removed, which were once supposed, by some, to militate strongly against the *possibility* of a *general Deluge*. Early geologists, for want of accurate information, supposed that all the waters of the globe were not sufficient to cover the whole earth, to such a depth as the sacred historian describes. It was asserted that the mean depth of the ocean did not exceed a quarter of a mile, and that only half of the surface of the globe was covered by it. On these data, Dr. KEIL computed that *twenty-eight* oceans would be requisite to cover the whole earth, to the height of *four miles*, which he judged to be that of the highest mountains; a quantity, which, at that time, was utterly denied to exist. But further progress in mathematical and physical knowledge has since shown, that the different seas and oceans contain at least *forty-eight* times more water than they were supposed to do, and much more than enough for the extent ascribed to the deluge in the sacred history.[u]

While difficulties which were supposed to render the deluge *impossible* have been removed, by the investigations of modern philosophers, many facts have been, at the same time, brought to light, showing the *probability*, and even *certainty* of that mighty inundation. In every valley and mountain support for revelation has been found. *Marine*

[u] M. DE LA PLACE (whose mathematical and astronomical skill will not be questioned, and whom none will suspect of a disposition to press facts unduly into the support of revelation) has demonstrated, by a strict application of the theory of tides, to the height to which they are known to rise in the main ocean, that a depth of water reaching only to *half a league*, or even to *two* or *three leagues*, is utterly incompatible with the Newtonian theory, and that no depth less than *four leagues* can possibly be reconciled with the phenomena. It will be readily perceived that this is much more than the Mosaic history requires. The extent of that part of our globe which is covered by water is now known to be far greater than KEIL supposed it; it being ascertained that nearly two-thirds of the surface of the earth are in this situation. KIRWAN's *Geological Essays*, p. 66, 67.

shells have been discovered in situations so elevated, and under circumstances so remarkable, as to prove that they were left there by a flood extending over the whole globe; and what confirms this conclusion is, that shells, peculiar to different shores and climates, very distant from each other, have been found in promiscuous heaps, plainly showing that they could have been brought together only by an extensive inundation. The bones of *elephants* and of *rhinoceri* have been found, in a multitude of instances, far distant from the regions in which they are found to live, and where, from the nature of the climate, they could never exist in the living state: and between the climates which they might have inhabited, and the places in which they are now found, too many mountains intervene to suppose them carried thither by any other means than a *general deluge*.[w] The most patient and accurate examinations of detached mineral substances, and of the strata of the globe, which late inquirers have made, afford every reason to believe, that the earth was, for a considerable time, wholly overflowed with water. And, to crown all, as voyagers and travellers have explored new regions of the earth, they have found, every where, the indications of geological phenomena confirmed and supported by the notices of tradition. Accordingly, it is very remarkable, that a great majority of modern theorists have embraced the *Neptunian* doctrines; and even such of them as rejected the Mosaic account of the deluge have been compelled to seek for other means of immerging the present continents in the ocean.[x]

w KIRWAN's *Geological Essays*, p. 54, *et seq.*

x M. BAILLY, of France, at first embraced the theory of the earth proposed by BUFFON; but finding the evidence arising from the universal tradition, so strongly to attest the reality of the general deluge, he abandoned that delusive theory, and

Finally, the researches of modern geologists have given abundant confirmation to the sacred history, not only with respect to the general *deluge*, but also with regard to the *age* of the earth.[y] Early in the century, and, indeed, until within a few years, several geological phenomena were considered, by superficial inquirers, as indicating that the creation of the globe we inhabit was an event much more remote than the sacred history represents it; and some theorists even went so far as to profess a belief that it existed from eternity. These opinions were kept in countenance only as long as geology was in its infancy. Every succes-

took refuge in another system, in which he recognizes the deluge, and only contends for placing it as far back as three thousand five hundred years before Christ.

y Sir William Hamilton and Mr. Ferber particularly applied themselves to the study of *volcanoes*, without giving general systems. They affirmed that the indications furnished by subterraneous and volcanic phenomena, and particularly by the beds of lava, announce the antiquity of the earth to be far greater than the sacred history represents it. But they did not advert to the fact, that all lavas are not composed of the same substance. All have not undergone the same degree of vitrification, and of course are more or less susceptible of decomposition. And even when their composition is the same, much depends on the state in which they are emitted. When poured from the crater in the fermentation of boiling liquefaction, a *scoria* or dross rises, like broken waves on the surface, and is easily pulverized by the air and weather. When the heat is less violent, or when the torrent is cooled in its course, an even and almost impenetrable surface defies the influence of the atmosphere. These philosophers do not recollect that *Herculaneum*, the date of whose destruction is well known, is covered by nearly *seventy* feet of lava, interspersed with *seven* distinct seams of friable earth; and the whole covered with good soil; yet all this has been the undoubted production of less than *eighteen hundred years*. Howard's *Thoughts on the Globe*.

In like manner, Count Borch, in his *Letters on Sicily and Malta*, professes to believe that *Ætna* is at least eight thousand years old, which he infers from the beds of vegetable earth which he discovered between different beds of lava. Yet M. Dolomieu, who has greatly distinguished himself by the acuteness and success of his geological inquiries, expressly tells us that such earth *does not exist* between the beds of lava of which the Count speaks, and thus destroys the foundation of his whole argument. But even if vegetable earth were found in the circumstances supposed, no conclusion relative to its age could fairly be deduced from this fact, as some lavas become fertile much sooner than others. The Chevalier Gioanni, in 1787, found lavas, projected in 1766, in a state of vegetation, while other lavas, known to be much more ancient, still remained barren. Kirwan's *Geological Essays*, p. 104, 105.

sive step which has been lately taken in the improvement of this science has served to show their fallacy. The investigations of the latest and most accurate philosophers have afforded proof little short of demonstration, that the earth, at least in its present form, cannot have existed longer than appears from the Mosaic account; the absolute falshood of many positive assertions, and specious inferences, hostile to the scripture chronology, has been evinced; and thence has arisen a new presumptive argument in support of the authenticity of that Volume, which contains the most ancient, and the most precious of all records.

METEOROLOGY.

The natural history of the *atmosphere* began to be cultivated, as a science, in the seventeenth century. The ancients, for want of the necessary instruments, were almost wholly unacquainted with it. But soon after the invention of the *thermometer* and the *barometer*, the learned men of Europe began to avail themselves of the manifest advantages which these instruments gave them, in studying the origin, nature, and effects of those changes which take place in the atmosphere, especially with respect to heat and cold, motion and rest, moisture and gravity: still, however, from the small number of the meteorological observations made by accurate philosophers; from the want of an extensive comparison of the results of different observations; and especially from the low state of those sciences most intimately connected with meteorology, little progress had been made in this department of knowledge prior to the commencement of the century under review. And though it must be acknowledged that this subject is one of those which are still far from

being satisfactorily developed, yet so much has been done, during the period under consideration, to throw light upon it, and so many observations and discoveries have been made, either directly or remotely relating to it, that it has, within a few years, assumed an aspect more interesting, practical, and approaching to the form of a system, than ever before.

At the commencement of the eighteenth century, the *ascent of water* in the atmosphere, in the form of *vapour*, had been but little investigated, and was very imperfectly understood NIEUENTYT and others had taught that the particles of fire, by adhering to those of water, made up *moleculæ*, or small bodies specifically lighter than air. Dr. HALLEY supposed that by the action of heat, the particles of water are formed into hollow *spherules*, filled with a finer air, highly rarified, of less specific gravity than the atmosphere, and, of course, disposed to rise in it. While Dr. DESAGULIERS thought that the ascent of aqueous particles was owing to their being converted into an *elastic steam*. Such was the state of opinions with regard to this fact, when Dr. HAMILTON, of Great-Britain, undertook the investigation of the subject, and proposed a new theory. He held that evaporation is the gradual *solution of water in air*, and that the former is suspended in the latter in the same manner as salts, or other soluble substances are suspended in aqueous fluids.[z] The same doctrine had been, in substance, suggested before by several philosophers, particularly by M. LE ROY, in 1751; by Dr. FRANKLIN, in 1756; and by MUSCHENBROECK, in 1769.[a] But though these and

z *Essay on the Ascent of Vapours*, &c. This Essay was first read before the Royal Society in 1765, and was afterwards published, with others, under the title of *Philosophical Essays*, by HUGH HAMILTON, D. D. F. R. S.

a Bishop WATSON's *Chemical Essays*, vol. i. p. 317.

some others, had spoken of the solubility of water in air, before Dr. HAMILTON, yet he was the first who treated the subject with precision, or who applied it systematically to the explanation of meteorological phenomena. This opinion was afterwards, in substance, adopted by Dr. HUTTON, and exhibited in his ingenious *Theory of Rain*,[b] and continued for a number of years to be the popular doctrine.

In 1786, M. DE LUC, of Geneva, published a new theory on this subject,[c] which has been since generally considered as superseding the doctrine of HAMILTON and HUTTON. Observing that evaporation takes place in *vacuo*, as well as in the open air, M. DE LUC rejected the opinion that vapour is the solution of water in air, and taught that this effect is produced by the chemical *combination*, or *union* of the particles of *heat* with those of water. Hence he accounted for the great loss of sensible heat, in every process of evaporation, according to the celebrated doctrine of *latent heat* taught by Professor BLACK. He made a number of curious observations and experiments on this subject, by which he ascertained that water, after this ascent in the atmosphere, does not exist in a sensibly *humid* form; whence he concluded that it passes into a form entirely different from itself, and probably becomes air. This doctrine is evidently founded on the mutual convertibility of water into air, and the reverse, discovered by CAVENDISH and some later chemists. The same theory, of the solution of water in heat, was also embraced by M. LAVOISIER, and appears to be now the most fashionable mode of interpreting the phenomenon in question.

b *Transactions of the Royal Society of Edinburgh*, vol. i.

c See *Recherches sur les Modifications de l'Atmosphere*, par J. A. DE LUC. 8vo. 2 vols. Geneva. 1772. And also *Idees sur la Meteorologie*, a more full and satisfactory work, by the same author. 1786.

Besides forming and giving to the world this ingenious theory of evaporation, M. De Luc has also rendered essential service to the science of meteorology, by his patient and persevering observations on the comparative degrees of moisture in the atmosphere, in different situations. On this subject he has brought to light a number of facts equally new and interesting. His countryman, M. De Saussure, has also laboured very successfully in the same field of inquiry;[d] and though not always with an entire coincidence of opinion and result, yet with sufficient agreement on most important points. There are probably no two individuals to whom the scientific world is more indebted for the minuteness, the accuracy, and the success of their meteorological investigations, than to these philosophers of Geneva.

About the year 1755 Mr. Eeles first suggested the probable influence of *Electricity* in the process of evaporation. He taught that there was but one way of altering the specific gravity of the particles of water, so as to render them lighter than air, and, consequently, buoyant in that fluid, viz. the adding to each particle a sufficient quantity of some fluid which possesses much greater elasticity and rarity than air. Such a fluid is *Electricity*; which, therefore, he supposed to have a very important agency in the ascent of vapours. The influence of the electric fluid in producing changes in the atmosphere has been since further investigated, and the principles on which it operates more satisfactorily developed, by Franklin, De Saussure, Bertholon, and other modern inquirers.

Closely connected with the doctrines which have been taught on the subject of evaporation are the several theories of *Rain* to which modern

d *Essai sur l'Hygrometrie*, 4to. 1783.

times have given birth. The phenomenon of vapour becoming condensed, or of air in any manner producing water, and falling in the form of *rain*, *hail*, and *snow*, has long been considered a point of difficult solution among meteorologists. All the suppositions to account for this fact were, for a considerable time, insufficient and unsatisfactory; and even now the subject is far from being fully unfolded. At one time the condensation and fall of vapour, in different forms, has been accounted for by referring to the influence of *Electricity*; at another, by considering water as held in solution in air, and *precipitated*, by streams of air of different temperatures being brought into contact, or a state of mixture; and, at a third, by supposing this event to be produced by the conversion of oxygen and hydrogen gases into water, according to the experiments of CAVENDISH, LAVOISIER, and others. These several opinions have been successively popular in the course of the century, and will be found amply detailed in the writings of HAMILTON, HUTTON, DE SAUSSURE, and DE LUC, on this subject. But, after all, it must be acknowledged, that great difficulties attend every theory hitherto formed with a view to solve this question. Insomuch that the greatest meteorologist of the age, M. DE LUC, after making a more patient, accurate, and thorough inquiry into the subject than was ever accomplished by any other man, seems to be at a loss to furnish a satisfactory account of the matter. He therefore contents himself with concluding, that the air, formed by the decomposition and ascent of water, becomes reconverted into that fluid, by some unknown cause, or by a combination of causes, and falls in the form of rain, hail, or snow, according to the circumstances in which the reconversion takes place, or the state

of the regions through which it passes in its descent.

Much light has been thrown, in the course of the last century, on the varieties of *temperature*, in different seasons and latitudes. On this subject Dr. Halley made some instructive observations. A few years afterwards, M. De Mairan, an ingenious French meteorologist, by a series of observations and experiments, discovered that the rigour of the winter's cold is tempered by the heat imparted to the atmosphere by the earth itself; and thus explained by what means the winter's cold is rendered so moderate as to make the colder climates inhabitable. On the ground of this discovery he calculated, with great sagacity, the *maximum* and *minimum* of heat in every latitude, for the summer and winter solstices; and though his calculations are not always found to coincide with facts; yet they have proved highly instructive and useful to subsequent inquirers. De Mairan was followed by M. Mayer, the celebrated astronomer of Goëttingen, who, in a few pages, did more to solve the difficulties that occurred on this subject than any of his predecessors. He first pointed out to meteorologists the necessity of following the method long used by astronomers; namely, of first finding the mean of certain large periods, as years and months, gradually correcting the errors that may be discovered, and afterwards finding an equation whereby to correct aberrations arising from height and situation. He even proceeded so far as to give an equation to correct the effects of height, which in many cases approximates very nearly to the truth; but the equation by which, knowing the mean annual temperature of two latitudes, the mean annual temperature of every other latitude, and even of the pole itself, may be

found, has been pronounced his most important discovery.[e]

Mr. Kirwan has carried the discoveries and improvements of Mayer considerably further. By means of the equation formed by the philosopher of Goëttingen, but rendered much plainer and more simple, he has calculated the mean *annual* temperature of every degree of latitude between the equator and the pole. He has also calculated the mean *monthly* temperature of that part of the ocean which lies between the eightieth degree of northern, and the forty-fifth of southern latitude, extending westward as far as the *Gulph Stream*, and to within a few leagues of the coast of America; and for all that part of the Pacific Ocean reaching from 45°. north to 40°. south latitude, and from 20°. to 275°. east longitude. This immense tract of ocean he calls the *standard*. From these calculations he has deduced a number of important principles, of great practical utility, and which place him among the most distinguished meteorologists of the eighteenth century.

The origin, qualities, and laws of *Winds* have been diligently studied, during the period under consideration, but not with the same success that has attended inquiries into other branches of meteorology. No satisfactory theory has yet been formed on this subject, owing to the want of observations sufficiently numerous, of the exact times and places where they begin and cease to blow, but chiefly to our imperfect knowledge of the means by which great regions of air are either suddenly produced or destroyed. The discoveries of modern chemists evince that air is perpetually subject to increase and diminution, from its combination with other bodies, or its evolution from

e See *An Estimate of the Temperature of different Latitudes*, by Richard Kirwan, *Esq.* F. R. S. &c.

them; and, therefore, that a just theory of winds, whenever it shall be formed, will be found to rest upon chemical principles, there is much reason to believe. But though little has been done in anemology, in the way of scientific reasoning, much has been accomplished, during the period under review, in the way of patient observation, and the establishment of numerous important facts. For these we are chiefly indebted to Dr. HALLEY, M. DE LA BAILLE, M. PREVOST,[f] M. DE LA COTTE, Mr. DALTON,[g] and several of the distinguished meteorologists before mentioned, especially M. DE LUC, and Mr. KIRWAN. To these may be added Dr. FRANKLIN, Dr. MADISON, Dr. CUTLER, and several other American gentlemen, who have made and recorded valuable observations on the winds in America;[h] and a long catalogue of modern navigators and travellers, who have contributed rich materials, brought from the most distant parts of the globe, toward forming a systematic view of anemology.[i]

Besides the great meteorologists whose names have been already mentioned, very important services have been rendered to this branch of natural history, by BOUGUER, DU CARLA, HALES, WARGENTIN, MARIOTTE, REYER, TOALDO, PRIESTLEY, and many others, to whom due honour is given by various writers on the subject. The volumes of *memoirs* published by the scientific academies, in different parts of Europe, during the century under review, contain rich treasures of meteorological information, contributed by numerous hands.

f *Sur les Limites des Vents Alizes.*

g *Meteorological Observations*, 8vo. 1793.

h For the observations of the above-named American gentlemen, and several others, see FRANKLIN's *Philosophical Letters*, and the volumes of *Transactions* which have been published by the *American Philosophical Society*, and the *American Academy of Arts and Sciences.*

i For some ingenious remarks on anemology, see *Botanic Garden*, additional notes.

Modern times have given birth to various inventions for measuring the force and velocity of winds. Among these the most remarkable are the *Wind-gage*, the *Anemoscope*, and the *Anemometer;* in the construction and improvement of which Dr. Linn, Mr. Pickering, and others, have rendered important service to meteorology. Numerous attempts have also been made, during the period under review, to construct *hygrometers*, or instruments for indicating the comparative states of the atmosphere, with respect to *moisture* and *dryness*. And though much imperfection is found to attend every instrument hitherto devised for this purpose, yet gradual approximations have been made toward those of a more perfect and useful kind. Among these Mr. Smeaton's *hygrometer*, formed of an *hempen cord*, boiled in salt water; M. De Saussure's, made of *hair*, prepared by maceration in alkaline ley; Mr. Coventry's, consisting of *dryed paper*; and M. De Luc's, of *ivory* and *whalebone*, deserve to be distinguished; especially that formed of *whalebone* by M. De Luc, which is generally considered as the most accurate and convenient hygrometer now in use.

That remarkable meteorological phenomenon, usually called the *Aurora Borealis*, appeared with peculiar frequency, in the course of the eighteenth century. Dr. Halley tells us[j] that it was seen but once in the seventeenth century, viz. in 1621, when it attracted considerable attention, particularly in France, where the celebrated Gassendi observed it, and gave it the name which it now bears. After this there is no record of any such appearance until 1707, when a small one was seen. But in 1716 an uncommonly brilliant one appeared, which commanded universal attention, and was

j *Philosophical Transactions*, No. 347.

considered by the vulgar as a most portentous event. Since that time these meteoric phenomena have been so frequent and familiar, that they have, in a great measure, ceased to attract attention, or to be recorded as remarkable events.

Modern philosophers have ascertained many facts with respect to the *Aurora Borealis*, which were, of course, unknown to those who lived in the seventeenth century, and probably to all who lived before them. It seems now to be generally considered either as an *electrical* phenomenon, or produced by the *combustion of inflammable air*, either with or without the intervention of the electric spark. For the observations which have been made upon this kind of meteor, and the principles with respect to it which appear to be established, we are under particular obligations to Dr. Halley, M. Mairan, Signor Beccaria, Dr. Franklin, Dr. Forster, M. Gmelin, M. Æpinus, Dr. Hamilton, of Dublin, Mr. Canton, Dr. Blagden, Mr. Dalton, and others. The last named gentleman is supposed to have given the most satisfactory account of the subject.

HYDROLOGY.

The natural history of *Waters* holds so important a place among the objects of human knowledge, that it has, in almost every age, attracted the attention of those who loved to study nature: but it is only within the century under review that any thing on this subject, deserving the name of science, or a correct acquaintance with principles, could be said to exist. The accessions to Hydrology in modern times have been very great. The improvements in Chemistry, in Mineralogy, and in many other sciences, have contributed much

to enlarge our knowledge in this department of philosophy.

The discovery of the *composition of water* was mentioned in a former chapter. The great augmentation of our knowledge, with respect to the doctrines of *tides*, during the period under review, was also noticed in a preceding division of this work. To repeat what has been said on these and some other subjects before discussed, and which might, with propriety, be introduced under this head, is altogether unnecessary.

But among the discoveries and improvements of the last age, which belong to this head, the most important are the numerous and very useful investigations of *Mineral Waters,* which have been pursued with great success during this period. It is evident that our knowledge of the properties and effects of mineral waters must, in general, keep pace with the progress of chemical science; for which reason the early writers on this subject were, in a great measure, destitute of the best means of pursuing their inquiries. The publications, therefore, of Drs. ALLEN, SHORT, RUTTY, HILLARY, SHAW, and others, of Great-Britain, who wrote on mineral waters early in the century; and of many cotemporary writers on the continent of Europe, who undertook to treat of the same subject, are of little value at the present day, excepting so far as they exhibit facts. But when the sciences of Chemistry and Mineralogy reached that stage of improvement which they attained in the hands of SCHEELE and BERGMAN, the analysis of mineral waters began to be pursued upon a new and improved plan. BERGMAN, in particular, about the year 1779, wrote very ably on this subject, and gave new and instructive views of it. About the same time, Messrs. MONNET and CORNETTE, of France, and GIAONNETTI, of Italy, displayed in

their respective works, considerable talents as hydro-analysts, and gave much valuable information to the world. These were followed by the excellent treatises of FOURCROY, on the waters of *Enghien;* of KLAHROTH, on the waters of *Carlsbad;* and of BLACK, on the waters of *Iceland.* In the experiments of these distinguished philosophers new and more accurate tests are exhibited; several improvements in the application of those before known are communicated; and methods unfolded of determining with precision the separate quantities of inseparable substances. Next appeared the publications of Drs. PEARSON and GARNET, and Mr. LAMBE, of Great-Britain, who, with great accuracy, analysed some of the mineral waters of their own country, and gave important information respecting them. In the same branches of mineralogical inquiry, the works of GREN, WESTRUMB, and KIRWAN, are also exceedingly valuable; especially that of the last-named gentlemen, who, in a tract singularly comprehensive, and abounding with instruction, has given a rich amount of principle, experiment, and authority, on this interesting subject.[k] The respectable publications of Drs. MUNRO, FALCONER, and SAUNDERS, are also entitled to notice, in recounting the names of those who have thrown light on the inquiry concerning mineral waters. By the labours of these, and many other philosophers, discoveries have been made, concerning the composition and medical powers of mineral waters, in almost every part of the world, extremely useful to the interests both of science and humanity.

k *Essay on the Analysis of Mineral Waters*, by RICHARD KIRWAN, Esq. F. R. S. &c. 8vo. 1799.

CHAPTER IV.

MEDICINE.

THE profession, whose department of knowledge now comes under consideration, occupy an immense field of science, and, by their number, constitute a large class of the learned world. In addition to the incentives of philanthropy and fame, which equally actuate the exertions of others, physicians are combined into a corps of observers and practical inquirers by the nature of the employment and duties they assume, and by the connection which the usages of society establish between their duties and emolument. In discharging their professional labours, they incessantly find observations and facts obtruded on their attention; and by combining these into hypotheses, theories and systems, they only indulge a favourite and almost irresistible propensity of the human mind. Hence arises the vast mass of writings which fill medical libraries, constantly accumulating, and too numerous, extensive and diversified to come within the comprehension of an individual inquirer. Whoever duly considers these things will perceive the necessity of resting satisfied on this occasion with a transient retrospect. To attempt any minuteness of detail would be to travel far beyond the limits assigned to this work, and to engross the pages which are destined to the examination of other subjects. All that can be aimed at is briefly to notice some of

the more important revolutions and improvements which distinguish the last age, and to commemorate a few of the illustrious names to whom the praise of them is chiefly due.[l]

Within the period assigned for this review, the state of medicine has been essentially changed, and has acquired a degree of extent, popular dissemination, and practical usefulness, unknown to preceding ages. The improvements in natural history and chemistry, mentioned in the preceding chapters, have greatly contributed to this extension, and may be considered as inexhaustible sources of materials calculated for a similar extension in future times. The more enlarged intercourse of mankind, the greater facility of communicating opinions and discoveries from one region to another, and the progress of commercial arrangements, by which the choicest productions of one country become the property of every other, may also be enumerated among the causes of this advancement.

In no period so much as in the last century, and in no science more than that which now engages the reader's attention, have the advantages been exhibited which arise from Lord Bacon's plan of pursuing knowledge by observation, experiment, analysis and induction. Every department of medicine bears witness of the efficacy of this process to remove the rubbish of prejudice and error, to present truth in a simple form, and to establish it upon a legitimate foundation. A more precise, rigid and logical mode of philosophising has been generally substituted for the wild and visionary hypotheses which disgraced the science of the preceding centuries.

l For many of the names, facts, and details included in this chapter, the author is indebted to a medical friend.

To understand the history of medicine at any period, it is necessary to trace the progress and mark the affinities of all the sciences which are contemporarily cultivated. Not only the reign of fashion, but the peculiar acquirements and taste of individuals are often to be considered in an estimate of their medical principles. "La Philosophie," says M. D'Alembert, "La Philosophie prend, pour "ainsi dire, la teinture des esprits ou elle se trouve. "Chez un metaphysicien, elle est ordinairement "toute systematique; chez un géomètre, elle est "souvent toute de calcul." The application of this remark, if possible, is more eminently verified in respect to medicine than to philosophy in general. This propensity of the human mind is productive both of good and ill effects. If it be easy to show examples of injury sustained by the precipitancy of mathematicians, chemists and metaphysicians, in applying their doctrines to medical science, which cannot indeed be reasonably doubted; it is equally easy to prove that great benefit has arisen from such applications.

But notwithstanding the advantages and improvements which the eighteenth century has bestowed upon medicine, it must still be admitted that its progress has never equalled the sanguine expectations formed by many. Although nearly coeval with the existence of mankind, and demanding attention in every stage and condition of human life, the art of healing maintains a struggle with difficulties at every step. Like all other knowledge derived from observation and experience, that of medicine, though continually progressive, is subject to perpetual revolution. This tardiness, therefore, in the career of improvement, which all must admit and deplore, will excite no surprize in such as consider the mystery which still envelopes the principle of life, the labour of watch-

ing the operations of nature, the numberless fallacies which attend the endeavour to discriminate truth from falsehood, and the smallness of the stock of genuine and undisputed facts which all the observation and wisdom of ages have been able hitherto to collect.

There is no species of knowledge, relating to affairs merely human, which more indispensably requires steadiness of principles and harmony of opinion than that now under consideration. There is none in which speculation and action are more intimately related, where error is of more immediate and fatal consequence, or where a fluctuation of the mind between opposite decisions is attended with more embarrassment and distress. Yet medicine abounds with schisms and controversies; and in the present imperfect state of knowledge, to hold doctrines and adopt practices beset with the fewest errors constitutes the highest attainment within the reach of the human mind.

ANATOMY.

This subject was pursued with so much diligence soon after the restoration of learning in the fifteenth and through the two succeeding centuries, as to leave less than might be expected for the investigation of modern anatomists. LEONARDO DA VINCI made great progress in anatomical studies towards the close of the fifteenth century.[m] In the sixteenth century flourished the immortal VESALIUS, the founder of rational and systematic anatomy, whose works afford surprising proofs of

[m] This was the first man who introduced the practice of making anatomical drawings. These drawings, preserved in a British collection, excite astonishment at the depth and accuracy of his knowledge.

laborious and successful dissection. After him appeared SYLVIUS in France, COLUMBUS, FALLOPIUS and EUSTACHIUS, in Italy; whose discoveries and improvements were so numerous as to give a deep impression of the zeal and enthusiasm with which the knowledge of the structure of the human body was cultivated at that early period.

Soon after the time of the last mentioned writers the study of anatomy was gradually diffused over all Europe. The principal impediment to its progress, in that age, was the difficulty of obtaining human subjects for dissection; the want of which frequently made it necessary to dissect the bodies of brutes.

With the dawn of the seventeenth century new lights were shed upon anatomical inquiries from every quarter. At this time FABRICIUS AB AQUAPENDENTE, an eminent Italian teacher, published his account of the valves in the veins, which evidently affected the established doctrine of all former ages, that the veins carried the blood from the liver for nourishment to all parts of the body. The detection of these valves may also justly be supposed to have laid the foundation of the discovery of the circulation of the blood.

For Dr. HARVEY, the pupil of FABRICIUS, was reserved, soon afterwards, the noble discovery of the *circulation of the blood.* This was by far a more important step in the knowledge of animal bodies than had ever been made before, and gave a new spring to anatomical inquiries. In a few years after HARVEY's discovery, ASELLIUS, an Italian physician, found out the lacteals, or vessels which carry the chyle from the intestines. And about the middle of the seventeenth century PECQUET, in France, was so fortunate as to discover the *thoracic duct,* or common trunk of all the lacteals, which conveys the chyle into the subclavian vein,

At nearly the same period, the practice of dissecting living animals furnished the occasion of discovering the lymphatic vessels. RUDBEC, a young Swedish anatomist, was the first to detect them; and, after him, THOMAS BARTHOLINE, an anatomist of Denmark, who first appeared as a writer on the subject.

MALPIGHI, an eminent Italian, made great progress in anatomy soon after the period last mentioned. He was the first who used magnifying glasses with address to trace the early appearances in the formation of animals. He likewise improved anatomy by many other observations on minute parts of the body, by his microscopical labours, and by the dissection of animals. Between the middle and end of the seventeenth century, anatomy was much improved by the diligence of SWAMMERDAM, VAN HORN, STENO, and DE GRAAF. Professor DIEMERBROECK, of Utrecht, without much originality, compiled a work, which, for many years, was regarded among students as a standard authority.

Towards the close of the same century LEWENHOECK obtained great celebrity by his improvement on MALPIGHI's use of microscopes. Though many of the supposed discoveries of this anatomist, particularly his account of the composition of the red globules of the blood, and of animalcula observed in the semen, are now discredited; it must still be admitted that he advanced many steps in bringing to light the more minute parts of animal structure. NUCK likewise soon afterwards added to the stock of knowledge by his injections of the lymphatic glands. The anatomical plates of BIDLOO and COWPER, published about this time, are also entitled to respectful notice.

In the latter part of the seventeenth century anatomy was greatly advanced by the invention of

injections, and the method of making what are commonly called *preparations*. These two modern arts have been of great advantage in this science; they have introduced not only an unexpected degree of correctness, but an elegance in demonstrations which formerly could not have been supposed to be possible. They began in Holland under SWAMMERDAM and RUYSCH, and were afterwards employed in England by COWPER, ST. ANDRE, and others. RUYSCH possessed a singular excellence in injections, which has been supposed by many not to have been equalled since, and which certainly has not been surpassed. The anatomists of former ages had no other knowledge of the blood-vessels than such as they were able to obtain by laborious dissections, and by pursuing the smaller branches of them, upon favourable occasions, when they happened to be more than commonly loaded with red blood. But filling the vascular system with a bright coloured wax presents a distinct view of the large vessels, renders the smaller much more conspicuous, and makes thousands of the very minute ones visible, which, from their capillary size, their delicacy, and the transparency of their contents, would be otherwise imperceptible.

In this high state of advancement, anatomy stood at the beginning of the century whose progress and improvements it is the object of this work more particularly to explore. At that period, the Italian and Dutch schools held an undoubted superiority. This superiority, however, has been since much more equally divided among the British, French and German anatomists.

Early in the eighteenth century, anatomy was improved by the writings of RUYSCH, in Holland, and of COWPER, KEIL, DOUGLAS, CHESELDEN, and others, in Great-Britain. The works of ALBINUS,

WINSLOW, and the first MONRO, greatly contributed to the same end, and are familiarly known to all the cultivators of this science.

But the most memorable discovery that anatomy can boast in the eighteenth century is that of the *absorbent system*. It has been mentioned that RUDBEC and BARTHOLINE became acquainted with the lymphatic vessels about the middle of the preceding century. When they were first seen and traced into the thoracic duct, it might have been supposed natural for anatomists to suspect, that as the lacteals absorbed from the cavity of the intestines, the lymphatics, similar in figure and structure, might possibly perform the same office with respect to other parts of the body. Notwithstanding this, anatomists in general, from repeated experiments, particularly such as were made by injections, were persuaded that these lymphatic vessels did not arise from cavities, and did not absorb, but were merely continuations of the small arteries. It had indeed been supposed by Dr. GLISSON, who wrote in 1654, that they arose from cavities, and that their use was to absorb. Dr. FREDERICK HOFFMAN had also very explicitly laid down the doctrine of the lymphatic vessels being a system of absorbents. These suggestions, however, produced little effect. And it was reserved for Dr. HUNTER, of London, and Dr. MONRO, the present professor at Edinburgh, to prove that the lymphatics are absorbing vessels throughout the whole body; that they are similar to the lacteals; that all these collectively taken, together with the thoracic duct, constitute *one great and general system*, dispersed through the whole body, for the purpose of absorption; that their sole office is absorption; and, finally, that they serve to take up and convey whatever is *to enter the composition of the blood*, or *to be again mixed with the blood*, from the intesti-

nal canal, from the skin, and from all the internal cavities and surfaces.[a]

The discovery of the absorbent system is justly considered as the greatest that anatomy has suggested since that of the circulation of the blood. The advantages which arise from the knowledge of the structure and office of this system of vessels in establishing physiological principles, and in ascertaining the nature and treatment of diseases, are universally admitted. Before the discovery of the lymphatics being a system of absorbents, it was impossible to give a clear and consistent account of a great number of phenomena which are now satisfactorily unfolded. From this source much knowledge has been obtained concerning the introduction and effects of poisons; and, aided by this light, physicians are enabled to trace many diseases directly to their causes, to explain the assemblage and succession of symptoms, and to apply remedies with more prompt and appropriate efficacy. On this account physicians of learning and judgment have not been wanting who pronounce the solid and practical usefulness of this discovery even to exceed that of the circulation of the blood.

But whatever may be the comparative estimate of the two discoveries in relation to one another, it is plain that they are both the most memorable

[a] A warm controversy, concerning the discovery of the true use of the lymphatics, was carried on between Dr. HUNTER and Dr. MONRO. The former asserts that he taught it in his lectures so early as 1746, and appeals to his pupils for the truth of the assertion. The latter seems to have made the discovery in 1753; and in 1755 published an account of it in a thesis *De Testibus in Variis Animalibus*. Before the publication of this thesis Dr. BLACK is said to have informed the author that the same opinions concerning the valvular lymphatics had been long entertained by Dr. HUNTER. In 1756 Dr. MONRO attended Dr. HUNTER's lectures in London; heard the whole doctrine of the lymphatics very amply explained; and in 1757 reprinted his opinion at Berlin, without taking notice of Dr. HUNTER's, who, in consequence, charges him with plagiarism; and the charge is retorted by Dr. MONRO.

that the annals of anatomy can boast. Under the influence of this impression, Dr. HUNTER declared, in one of his lectures, that "in looking over the "whole progress of anatomy, from the time of "Aristotle to the present day, there have been "only *two grand discoveries* with regard to the "physiology of our bodies; to wit, the *Vascular* "*system, or circulation of the blood*, and the *Ab-* "*sorbent system;* the *Brain* and *Nervous system* "having been known long before."

Notwithstanding, however, the weight of the arguments adduced by Dr. HUNTER, Dr. MONRO, and others, in support of this doctrine of the absorbent system, it has been opposed by writers of great authority. The old opinion, that the veins perform the office of absorbents, was held by HALLER[n] and MECKEL. Within a few years, Mr. HUMPAGE, in a work entitled "Physiological Re-"searches into the most important Parts of the "Animal Economy, &c." undertook to controvert the prevailing doctrine on this subject. He endeavours to prove, conformably to the opinion of the old anatomists, that the lacteals and lymphatics constitute systems of vessels entirely separate and distinct. He admits that the lacteals arise from the internal surface of the alimentary canal, terminate in the thoracic duct, and convey the chyle into the blood. But he denies that the lymphatics arise from cavities and surfaces, or that they terminate in the thoracic duct; and maintains, on the contrary, that they originate from the heart and arteries, that they serve to convey lymph from the blood, and that they terminate on all surfaces and cavities. He contends that the use of the lymphatic glands is for the separation of the lymph from the blood; and that the lymphatic vessels are

n *Element. Physiolog. Corp. Human.* l. 24. § 2, 3.

excretory ducts to the lymphatic glands. For the important function of absorption he provides in the following manner. He supposes that, although the lymphatic vessels convey fluids from the blood, they also occasionally possess the power of absorption. This office, he imagines, they perform after accomplishing their first purpose; that is to say, after conveying the lymph to the various parts of the body, they become mere empty tubes, and absorb whatever is applied to any surface. According, therefore, to the degree of inanition or repletion of the lymphatic vessels, in his opinion, will the body be more or less susceptible of the absorption of any fluid applied to the skin, or any other surface or cavity.

These, however, and many other objections to the generally received doctrine of the absorbent system, have gained little credit among the most respectable anatomists. The arguments by which they are attempted to be supported have been shown to be founded on injections unskilfully made, on observations inaccurate, and conclusions altogether illogical.

In the early part of the controversy on this subject, it was urged, that, before the doctrine of the lymphatics being a system of absorbents could be established, it was necessary first to determine whether this system is to be found in other animals besides man and quadrupeds. Mr. Hewson claimed the merit of having proved the affirmative of this question, by discovering the lymphatic system in birds, fishes, and amphibious animals.[p]

Since the time of Mr. Hewson, the anatomy of the absorbent system has been greatly extended and improved. The ramifications of it, in almost every part of the body, have been traced by Mr.

[p] *Philos. Transac.* vol. lxviii & lxix.

CRUIKSHANK, with great accuracy; and from his dissections, figures have been made and published which are deservedly held in high estimation. To Mr. SHELDON also, anatomists are much indebted for his illustration of this system. And MASCAGNI, of Italy, has likewise bestowed great pains on this subject.

As a general system of anatomy, the "Anatomical exposition of the structure of the human body," by Professor WINSLOW, of the University of Paris, though compiled and published early in the eighteenth century, was, till near the close of it, regarded as a standard work. This has, of late, given place to a more comprehensive and accurate compilation, in three volumes, executed by Mr. FYFE, of Edinburgh, under the direction of Professor MONRO. HEISTER's compendium, during a great portion of the century, was held in high esteem. Dr. SIMMONS, of London, has also lately obliged the world with an excellent system of anatomy, in which the subject is treated with uncommon perspicuity and elegance. Among treatises on anatomy in general, those presented to the world by SABATIER and PLENCK, within a few years, deserve to be particularly mentioned. Mr. JOHN BELL, of Edinburgh, has published two volumes of a system of anatomy, which is considered as a very able work, so far as it goes, and will probably be completed in a short time. Mr. CHARLES BELL, of the same city, in a work entitled "A System of Dissections," has done much towards facilitating and familiarizing the study of anatomy, and displaying the appearances of morbid parts of the body. And a very recent "Compendium of Anatomy" by Mr. FYFE, above-mentioned, illustrated by a large number of engravings, is supposed to contain improvements, of more or less value, on every preceding work of that kind.

To the above may be added a variety of valuable publications by Professor SCARPA, of Pavia, who has well supported the reputation of the former Italian schools of anatomy.

In particular departments of anatomy much has been done within the century, to enrich the science, which ought not to be passed without special notice.

The *gravid uterus* is a subject which has attracted much attention, and received considerable improvement, within this period. The works of ALBINUS, ROEDERER, and JENTY, have greatly enlarged the knowledge of former anatomists on this point. But Dr. HUNTER's publication on the gravid uterus, to which he had devoted a long time and uncommon pains, far excelled every preceding work. MECKEL, and the second MONRO, have treated of the *nerves* to considerable extent; WEITBRECHT and LEBER on the *joints* and *fresh bones;* SOEMERRING and MONRO on the *brain;*[q] PORTERFIELD, HALLER, ZINN, and WRISBERG on the *eye;* COTUNNIUS, MECKEL, jun. CAMPER, SCARPA, and many others, on the *ear*. WALTER is celebrated for his description of the *veins of the head and neck*, as well as very elegant plates of the *nerves of the thorax and abdomen*. TREW has ably treated of the *dif-*

q Mr. SOEMERRING thinks it probable that the *soul* is seated in the fluid of the ventricles of the brain. He infers this from the fact of the nerves of vision, hearing, taste and smell being all at their origin in contact with and exposed to the action of the fluid in the ventricles; from the same taking place with regard to the nerves of touch, originating from the fifth pair, the glosso-pharyngeal, those belonging to the organ of voice and the motions of the eyes; from the impossibility of finding a solid part of the brain into which the terminations of all the nerves can be traced; from the nerves of the finest senses, viz. hearing and seeing being most extensively expanded and most directly in contact with this fluid; from the preternatural increase of this fluid in the ventricles of ricketty children, which perhaps may be the cause of their uncommon acuteness of mind; and, finally, from the fact, that no animal possesses so capacious and so perfectly organized ventricles as man, they being in the other mammalia much smaller than in man, still less in birds, least of all in fishes, and absolutely wanting in insects.

ferences between the fœtal and adult vessels; Dr. MONRO, jun. on the *Bursæ Mucosæ*, &c.

The anatomists of the eighteenth century have effected great improvements in the science, and facilitated the communication of it to students, by the number and correctness of their *engravings*. Figures of the *bones*, in folio, have been published by CHESELDEN, ALBINUS, SUE and TREW. The *muscles* are exhibited by COWPER and ALBINUS with great accuracy; by the latter particularly in a style of elegance which cannot easily be surpassed. HALLER's *Icones*, especially of the *arteries*, are much admired. Anatomical figures of particular and smaller parts of the body are without number, and many of them possess great excellence. It will be sufficient to mention a few; such as those by MORGAGNI, RUYSCH, VALSALVA, SANCTORINI, HEISTER, VATER, CANT, ZIMMERMAN, WALTER, &c.

The vast work, projected by VICQ-D'-AZYR, of France, was soon terminated by his premature death. He conceived the idea of representing anatomically the whole animal kingdom, from man down to the simplest hydra, of giving exact figures of every form of living matter, and of consolidating the immense plan into one great whole. Upon the *brain* alone nineteen folio plates are employed, of which several are coloured; these are executed with admirable elegance. This universal system of anatomy and physiology, both human and comparative, was proposed to be executed in the same splendid style. But he lived only to finish five numbers. The design is apparently too extensive to be accomplished within the period of a single life.

In Great-Britain, likewise, an extensive anatomical work has been undertaken by Mr. ANDREW BELL, entitled, *Anatomia Britannica*, under the

inspection of Mr. Fyfe and Dr. Monro. It is designed to compose a complete illustration, both general and particular, of the human body, by a selection from the best plates of all the greatest anatomists, as well foreign as British, exhibiting the latest discoveries, and accompanied with copious explanations. The whole number of plates is to be upwards of three hundred, in royal folio, of which a large proportion are already published.

The art of *injection* and of making *preparations*, which was before stated to have reached such a point of excellence towards the close of the seventeenth century, has been very extensively and successfully exercised during the eighteenth. The modern practice of corroding the fleshy parts and leaving the moulded wax entire, is so useful as well as ornamental, that it reflects great credit on Dr. Nicholls, the ingenious inventor. In the injection of the lacteals and lymphatics the late century may justly claim the credit of having made very considerable progress.

Morbid dissections form a new and interesting era in anatomy and medicine. Bonetus, near the end of the seventeenth century, had published his *Sepulchretum Anatomicum.* Morgagni, in his inestimable work, " *De causis et Sedibus Morborum*," has enriched morbid dissections with many precious additions, and has rendered them highly instructive to the medical practitioner. Lieutaud and Haller have also greatly increased the stock of knowledge on this point. Most of the distinguished anatomists, indeed, have contributed their exertions to improve the principles of medicine, by directing their dissections to this object. Lately Dr. Baillie's publications on morbid anatomy, illustrated by correspondent engravings, do the highest honour to his diligence, learning, and judgment.

Besides the discoveries and improvements obtained from the dissection of human bodies, *Comparative Anatomy* or *Zootomy* has made great progress in the course of the eighteenth century. Many advantages have arisen, and may be expected hereafter to arise, from this source. In addition to the benefits resulting from a more enlarged acquaintance with the properties and functions of animated nature, which often reflect light on the human economy, and are founded in the knowledge of comparative anatomy, the *veterinary* art has lately become so extensive and respectable as to require, on its own account, a more minute examination of the structure of many animals.

The most illustrious names among such as have distinguished themselves in human anatomy, are in general precisely those who have done the most to extend the limits of comparative anatomy in the eighteenth century. To prove this it will be sufficient to recal the reader's attention to the writings of HALLER, Dr. and Mr. HUNTER, the first and second MONRO, &c. The *Essay on Comparative Anatomy*, by the first MONRO, affords proof of the diligence he exercised on the subject. The thesis of the second MONRO, "*De testibus in variis animalibus*," abounds with evidence of deep, laborious and successful researches. And his work on *Fishes*, mentioned in the preceding chapter, has greatly contributed to enlarge our acquaintance with the structure and functions of that large class of animals. Every anatomist is informed of the discoveries and improvements made by Dr. and Mr. HUNTER in their numerous dissections of animals, and of the principles and doctrines which these dissections enabled them to establish. They were followed by Mr. HEWSON, Mr. CRUIKSHANK, and many others of distinguished reputation, who were employed in the investigation of

the absorbent system. DAUBENTON and VICQ-D'-AZYR, of France, the dissections made under the orders of the Royal Academy of Sciences of Paris, SPALLANZANI, of Italy, CAMPER, of Holland, the late extensive and systematic work of Mons. CUVIER, which exhibits the dawn of an improved arrangement, and a great number of the most eminent zoologists of the age, have strong claims to be commemorated in a review of the comparative anatomists of the eighteenth century.[r]

In concluding this brief survey of the subject, it may not be improper to remark that far less remained to be done in anatomy, at the commencement of the late century, than in any of the other branches of medicine. The leading principles of the science had been chiefly ascertained and settled by the industry and perseverance of preceding ages. And the greater part of what was left to be accomplished consisted in a superior fulness, accuracy, and minuteness of description, more elegance of delineation, more neatness and variety of preparations, and a progressive improvement in the arts of dissection and demonstration. It is evident that, in all these respects, a considerable progress has been made within the period under review.

PHYSIOLOGY.

That department of physical science which treats of the various properties and functions of

r In addition to the above-mentioned works and names, it may not be improper to subjoin the following comparative anatomists, selected from a great number. Fragments of the *Curieux de la Nature;* the collections of BLASIUS and VALENTINI; DU VERNEY, COLLINS, STUBBS, COLEMAN, and HOME, on *quadrupeds and birds;* CHARAS, ROESEL, and FONTANA, on *reptiles;* ARTEDI, the GOUANS, and BROUSSONET, on *fishes,* REAUMUR, the GEOFFROYS, BONNET, and LYONNET, on *insects;* and ELLIS, DONATI, TREMBLEY, BAKER, BASTER, BOHADSCH, FORSKAL, ADANSON, MULLER, PALLAS, and DIQUEMARE, on *worms, zoophytes* and *polypes.*

living bodies must be allowed to possess great importance; and the review of its progress during an hundred years of more industry and enterprize in the pursuit of natural knowledge than the world has ever witnessed before, will be supposed to present difficulties proportioned to the extent and complexity of the subject.

To such as feel a genuine attachment to the science of nature, few subjects present inquiries of a more interesting and instructive kind. When improved as far as the state of the other cotemporary sciences will admit, it will be found to exhibit a systematic result of all the experiments and observations, facts and principles, which serve to explain and illustrate the phenomena of animated nature. And when it shall reach that point of advancement to which a cautious estimate of the powers of the human mind may suppose it to proceed, it will probably be enabled to diffuse lights and suggest improvements far beyond the most sanguine expectations of the naturalists of the present day. In zoology, botany, anatomy, and the theory and practice of physic, these good effects may be confidently anticipated.

As all living bodies are subjects of physiological inquiry, and as by living bodies are here meant all those which are enabled, by a certain organized structure, to grow and to propagate their kind, it is plain that physiology must extend to the whole of that organical economy in animals and plants which the author of nature has contrived for the preservation of the individual, and the continuance and propagation of the species. But although it is not intended, in this brief retrospect, wholly to overlook the history of the doctrines of general physiology for the late century, it may be proper to apprize the reader that the objects of human physiology will chiefly claim attention.

This restricted view of the subject is preferred, on the present occasion, not only on account of the requisite brevity, but because the chief design of introducing this sketch of the progress of physiology is to consider it in subserviency to medical science, and as preparatory to the remarks which are to follow concerning the theory and practice of physic.

At the close of the seventeenth century, physiology presented a chaos of the wildest and most discordant principles. The extravagant notions of the Galenists and Chemists had indeed ceased to be generally defended; but they were succeeded by those of the mathematicians, which were nearly as far removed from truth and nature. The discovery of the circulation of the blood, in the beginning of the seventeenth century, had given rise to the introduction of mechanics into medical doctrines. And as that system of philosophy was founded upon the general laws of nature, the ablest physiologists of the day were easily induced to apply it to the human body; which was supposed to differ only from the rest of the universe in the variety and complexness of its machinery.

Bellini, of Florence, was the first who attracted much attention by the introduction of mathematics into physiology. Professor Borelli pursued the same course of reasoning, and soon became one of its most enthusiastic admirers. He employed it so well in showing how the muscles act as cords, and the bones as levers, that he thence undertook to explain, with happy effect, the phenomena of standing, walking, leaping, flying and swimming, in different animals.[r] Emboldened by the success of his first attempt, he afterwards ventured to explain, on the principles of mecha-

[r] See his work, *De motu animalium*.

nism, all the internal motions and their proximate causes. On the same ground he gave a minute account of the pulsation of the heart, of the circulation of the blood, of the office of the lungs, the kidneys and the liver, of the nervous fluid, and the semen, of vegetation, generation, nutrition, hunger, thirst, pain, lassitude, and febrile heat. By this ardent speculatist all nature was interpreted on mathematical principles; for, except the mechanical, he was willing to admit no other secondary powers in nature. He thought, with Plato, that the Deity himself was always *geometrising;* and was fully persuaded that physical knowledge could only be acquired through the medium of geometrical demonstrations and forms.

With what eagerness and zeal Dr. PITCAIRN adopted mechanical physiology, and to what unreasonable extremes he was disposed to carry it, is sufficiently known. So attached was he to the geometrical mode of demonstration, that he appeared to consider it as the only species of evidence, excepting the senses, that deserved any reliance.

These opinions were warmly adopted and supported by the illustrious BOERHAAVE, who first appeared as a public teacher about the beginning of the eighteenth century. He exhibited the first successful example of combining physiology with anatomy, reduced the former from a rude and chaotic into a regular state, and conferred upon it that systematic and elegant form which so greatly recommended it to the notice and admiration of the world. But a more particular account of the opinions of this distinguished physician will be given under a succeeding head.

Baron HALLER, the disciple of BOERHAAVE, pursued the steps of his master, and far surpassed him in his physiological career. He made a universal collection of preceding discoveries in ana-

tomy and physiology, and digested them into order and method. He surveyed every part of the human body, explained the various functions according to the best lights which the state of science at that time afforded, corrected the errors of preceding writers, and by a series of indefatigable labours, was enabled to make very important additions to the existing stock of knowledge. In his great work, entitled *Elementa Physiologiæ Corporis Humani*, he examined the opinions which have been recommended, or, at least, advanced by all the most celebrated authors. Nothing of importance, that had been previously published, escaped his notice. The most rapid sketch of the errors in physiology which he detected, of the new facts which he added, of the ingenious and profound views which he opened, of the doubts he removed, and of the theories he reformed and improved, would exceed the limits assigned to this work.[t]

But the greatest of HALLER's discoveries, and that which forms an era in the progress of physiology, is the *irritability* of the animal fibre. This *irritable* or *contractile* power is that property by which muscles recede from stimuli, and become shorter on being touched by them. It is a power

[t] Baron ALBERT DE HALLER was born at Berne, October 18, 1708, and died in 1777. He was unquestionably one of the greatest men of the age in which he lived; being equally distinguished for the extent and variety of his learning, the vigour and comprehensiveness of his mind, the purity of his taste, and the excellence of his moral and religious character. His great attainments, and the uncommon powers which he displayed in almost every kind of knowledge, and particularly in anatomy, physiology, medicine, botany, and various branches of natural history, and also in classical and polite literature, are generally known. He was not less distinguished as a friend to the religion of Christ. He not only professed to believe in revelation, and to cherish a warm attachment to the gospel; but amidst his multiplied avocations, he spent much time in studying the scriptures, and the evidences of their divine origin; and entered the lists as their avowed advocate and defender. His excellent *Letters to his Daughter* will long remain a monument at once of his regard to religion, and of his paternal fidelity. See HENRY's *Memoirs of Albert de Haller*, M. D. &c. &c.

inherent in the muscular fibre, and essential to life. It is so far independent of nerves, and so little connected with feeling, which is the leading property of nerves, that, upon stimulating any muscle by touching it with caustic, or irritating it with a sharp point, or directing the electric spark through it, the muscle instantly contracts; although the nerve of that muscle be tied; although the nerve be cut so as to separate the muscle entirely from all connection with the nervous system; although the muscle itself be separated from the body; and although the animal upon which it be performed have lost all sense of feeling, and have been long to all appearance dead. It is by this irritable principle that an incised muscle contracts so powerfully; and that a divided artery shrinks and retires into the flesh.

This important *principle of irritability*, which HALLER denominated *Vis Insita*, from its being an inherent, independent and permanent property of the living fibre, was in a great measure unknown to preceding physiologists. BOERHAAVE acknowledged an active power in the heart, and a latent principle of motion in the parts of it when divided; but nevertheless he attributed this to the nerves, though the communication with the brain had been entirely cut off. The celebrated Dr. WHYTT, of Edinburgh, followed nearly the same path, with only some difference in point of expression. About the middle of the century now under consideration, this physician was engaged in a controversy with HALLER on this subject. WHYTT contended that all the phenomena of irritability might be referred to nervous influence, and rejected his antagonist's principle of muscular action, as founded in error, and unnecessary to explain the phenomena. On the contrary, to this *Vis Nervosa* of WHYTT, though maintained with all the aid of

ingenuity and learning, HALLER, with much greater force and conclusiveness of reasoning, persisted in opposing his doctrine of *Vis Insita*, as a primary, essential, and inherent quality of the living fibre, dependent on its original structure and organization, and entirely independent of the nerves. Not many years ago Professor MONRO, of Edinburgh, in his *Observations on the Structure and Functions of the Nervous System*, renewed the attempt, though it is conceived without success, to invalidate the doctrine of HALLER.

In pursuance of this interesting doctrine, HALLER contemplates the living body under a four-fold division, into parts, 1. Irritable; 2. Inirritable; 3. Sensible; 4. Insensible. Among *irritable* parts he ranks the heart, the muscles generally, the diaphragm, the œsophagus, the stomach, the intestines, the gall-duct, the arteries, the absorbents, and the bladder. Among *inirritable* parts he reckons the lungs, the liver, the kidneys, the spleen, and the nerves. Among *sensible* parts he enumerates the brain, the spinal marrow, the nerves, the skin, the internal membranes of the stomach, intestines, and bladder, the ureters, the muscular flesh, and the breasts. Among *insensible* parts he considers the dura mater, the pia mater, the periosteum, the peritonæum, the pleura, the pericardium, the omentum, the cellular texture, the cuticle, the rete mucosum, the fat, the tendons, the capsules and ligaments of the joints, the bones, the marrow, the teeth, and the gums.

From this account, given by HALLER, of the various parts which are united to form an animal system, it results that the *irritable* and *sensible* portions are comparatively few and small; that the great mass of the body consists of *inirritable* and *insensible* parts, which serve to combine, envelope and defend the former, and thereby to constitute a

moving perfect whole, adapted to assume the actions of life, and to sustain the impression of surrounding objects.

In this arduous inquiry, which so long engaged the mind of HALLER, and which led to so many interesting results, he was not condemned to the necessity of labouring alone. The example of the preceptor inspired many of his pupils with the same spirit of exertion and enterprize. ZINN, ZIMMERMAN, CALDANI, and several others, animated by a liberal emulation, laboured with indefatigable diligence to extend and improve the discoveries of their illustrious master. Thus, by the combined exertions of the teacher and his students, was the philosophy of animal life more deeply investigated than ever before, and eventually placed on a basis almost entirely new.

The effects of HALLER's doctrine of *irritability* in improving physiological and medical principles must be obvious to the most superficial observer. It will not be thought extravagant to say that he seems to have laid the true foundation of the science of medicine; if indeed such a foundation can be said to be yet laid. From HALLER, more than from any single writer, Dr. BROWN, and other modern systematic reformers, who have done most to improve medical principles, seem to have borrowed the torch by which they were enabled to direct their progress, and to explore the obscurities of their route.

But notwithstanding HALLER's felicity in accomplishing so much to aid the progress of physiology, he did not live to witness two of the most signal improvements in that science which the eighteenth century can boast. He died in the year 1777, just about the time when a new and unexpected light began to be shed upon the functions of *respiration* and *digestion*.

The office of the *Lungs*, which is now of all the animal functions the best understood and the most susceptible of scientific illustration, was unknown to HALLER. He supposed that the principal object of respiration was to form the voice. That such a man, possessed of all the knowledge of preceding and cotemporary physiologists on this subject, should have acquiesced in this conclusion, is indeed matter of surprize; but at the same time it serves to fix the source, and to enhance the value of this great discovery.

To modern chemistry the praise of unfolding the mystery of respiration is certainly due. The establishment of this truth alone is almost sufficient to subvert the old and to erect a new system of physiology. And if no other benefit than this had arisen from all the brilliant discoveries which chemistry offers to the world, it would have sufficed to rescue that science from neglect, and to assign it an elevated rank among the objects of human knowledge.

It is often asserted that much of the true office of the lungs was known to the physiologists of the seventeenth century. Even from much more ancient writers expressions sometimes escape which show a tendency to just views of the subject; as for example, when air received in respiration is supposed to afford the *pabulum vitæ, spiritus alimentum*, &c. But in the century just mentioned a much nearer approximation to the truth was undoubtedly made. VERHEYEN observed that those animals which respire most have the warmest blood.[v] LOWER demonstrated that the blood receives a new and a brighter colour in passing through the lungs.[u] VERHEYEN and BORELLI both

v *Tract. De usu Respirationis.*
u *Ibid.*

proved that the air lost something by coming in contact with that organ.[w] And the former remarked that this *something* is absorbed by the lungs; is probably that which maintains combustion, which qualifies the air to support animal life, and imparts to the blood the vermilion colour.[x] Towards the latter part of the same century Dr. HOOK and Dr. MAYOW published opinions concerning respiration, which approach more nearly to the doctrine now generally received than could be readily believed if their writings themselves did not bear witness. The former seems to have been obscurely acquainted with oxygen and its absorption in breathing. The latter, according to the opinion of Dr. BEDDOES,[y] "was acquainted with "the composition of the atmosphere, and perceived the action of *vital air* in almost all the "wide extent of its influence. He carried on his "investigation of respiration from the diminution "of the air by the breathing of animals, to the "change it produces in the blood during its passage through the lungs. The office of the lungs, "says Dr. MAYOW, is to separate from the air, and "convey to the blood one of its constituent parts."

It is astonishing that such suggestions should have been so little known and so little attended to by succeeding physiologists. They seem to have attracted but slight regard at the time of their publication, and very soon afterwards to have been completely forgotten. But, after all, it must be admitted that the superior light of modern discoveries, reflected on organs of eager discernment, is alone sufficient to enable the reader of those antiquated writings to perceive, in the few truths they contain, blended and buried under so much obscu-

w *Tract. De usu Respirationis.*

x *Ibid.*

y See Dr. BEDDOES's *Analysis of Dr.* MAYOW's *Work.*

rity, mistake and error, the true principles of respiration.

There cannot be stronger proof of the fact that these obscure hints of the real use of respiration were unknown or forgotten by succeeding physiologists, than may be found in the works of HALLER and Dr. WILLIAM HUNTER. The opinion of the former of those great physiologists, concerning the subserviency of respiration chiefly to the formation of the voice, has been already mentioned. The latter, in his introductory lecture, published in 1784, expresses himself as follows: "Respiration "we cannot explain; we only know that it is, *in* "*fact*, essential and necessary to life. Notwith-"standing this, when we see all the other parts of "the body, and their functions so well accounted "for, we cannot doubt but that respiration will be "so likewise. And *if ever* we should be happy "enough to find out clearly the object of this func-"tion, we shall, doubtless, as clearly see, that *this* "*organ* is as wisely contrived for an important "office, as we now see the purpose and importance "of the heart and vascular system; which, till "the circulation of the blood was discovered, was "wholly concealed from us."

It will scarcely be necessary to add to what is already stated concerning HOOK and MAYOW, that Mr. BOYLE and Dr. HALES were much engaged on the same subject, and that the latter particularly was greatly useful by his experiments and researches in pneumatic philosophy, which paved the way for the brilliant improvements of his successors in that inquiry.

The splendid progress of pneumatic chemistry which ennobles the last twenty-six years of the eighteenth century, has been detailed in another place. The discovery of *oxygen*, and the analysis of the atmosphere, are prominent points in that pro-

gress; and they likewise constitute the basis of the principles which were afterwards so successfully applied to explain the nature and objects of the function of respiration.

It is universally known, that the merit of taking the lead in the application of the principles of pneumatic chemistry to explain the function of the lungs, is due to Dr. PRIESTLEY.[z] In the year 1774 he discovered the existence, and many of the properties, of *oxygen*. Mr. SCHEELE made the same discovery nearly at the same time. Not long afterwards these two philosophers demonstrated that the quantity of oxygenous gas is diminished in respiration. In 1776 LAVOISIER proved that atmospheric air is compounded of oxygen and azote, brought by means of caloric to the state of elastic fluids. In the following year that eminent philosopher discovered that a quantity of carbonic acid gas is found in air after it has been respired for some time, which did not previously exist in it. Some time afterwards he found, by a variety of experiments, that no animal can live in air totally deprived of oxygen. This fact was soon confirmed and extended by the experiments of many other philosophers, who proved that even fishes, which do not perceptibly respire, and frogs, which can suspend their respiration at pleasure, speedily die if the water in which they are placed becomes destitute of oxygenous gas.[a]

By a further prosecution of observations and experiments on this subject, it was not long afterwards satisfactorily established, that certain remarkable changes are produced by respiration not only upon the air respired, but likewise upon the

z For a considerable portion of the facts detailed in several of the following paragraphs, on the subject of *respiration*, the author is indebted to a very respectable work, entitled, *A System of Chemistry*, by THOMAS THOMSON, M. D. 4 vols. 8vo. 1802.

a CARRADORI, *Ann. de Chim.* xxix. 171.

blood exposed to this air. The most noted changes observed to take place in the air itself subjected to respiration are the following: a part of the air respired entirely disappears; the rest becomes impregnated with carbonic acid, and is loaded with water in the state of vapour. For the knowledge of these changes effected in the air respired, and for the numerous and laborious experiments from which these conclusions were inferred, the world is chiefly indebted to PRIESTLEY, CIGNA, LAVOISIER, MENZIES, SEGUIN, and DAVY.

Changes no less remarkable are found to be produced in the blood exposed to the air in the lungs. The principal of these are as follow: the blood absorbs air; it acquires a florid red colour, and the chyle mixed with it undergoes such alteration as to lose its colour and disappear; it emits carbonic acid, and perhaps carbon itself; and it emits water, and perhaps hydrogen. The writers who have principally signalized themselves in tracing and making known these changes in the blood, are PRIESTLEY, CIGNA, FOURCROY, HASSENFRATZ, BEDDOES, WATT, and, very lately, Mr. DAVY.

The theories of this function, as deduced from facts successively discovered, have varied according to the number of such facts, and the impressions which they made on different minds. Dr. PRIESTLEY, the first of the modern chemical philosophers, as was before remarked, who attempted to investigate the use of respiration, seems to have considered it, from some of his earliest experiments, chiefly as an excretory process. He believed that the blood, in passing through the lungs, gives out *phlogiston* to the air, which, when expired, he supposed to be loaded with that substance, and, consequently, that the main purpose of respiration is to discharge phlogiston from the blood.

Soon after these conclusions had been formed by Dr. Priestley, M. Lavoisier directed his efforts to ascertain, with as much precision as possible, the changes which the air undergoes in the process of respiration. In order to explain this function he framed a theory, which assumed, as its basis, that all the changes produced on the air inspired are produced in the lungs; and, of consequence, that all the new compounds and substances detected in the air expired, are formed in the lungs. It was a principle of this theory, that the blood absorbs no air in the lungs; but that it discharges hydrogen and carbon, which, combining with the oxygen of the air inspired, form water and carbonic acid. This theory was adopted by La Place, Crawford, Gren, and Girtanner, with some small modifications, which it is unnecessary here to particularize. Upon close inspection, it appears that this theory of Lavoisier does not materially differ from the original hypothesis of Dr. Priestley, viz. that the object of respiration is to free the blood of *phlogiston*. The difference consists chiefly in terms and in detail. For if carbon and hydrogen be substituted for phlogiston, which is often necessary in reconciling the statement of facts delivered by the *phlogistians* and *antiphlogistians*, the two theories will be found entirely to agree. M. Lavoisier did little to establish his theory by proof. He only attempted to prove that the amount of oxygen absorbed in respiration exactly corresponds with the quantity of it contained in the carbonic acid and the water emitted. But as this coincidence of quantities cannot be proved, his theory is unsupported, so far as the establishment of it depends upon such coincidence.

Afterwards, when a greater number of facts and illustrations of this subject had been collected, a different theory was offered by La Grange. Ac-

cording to him, the *oxygen* which disappears in respiration combines with the blood in its passage through the lungs, and at the moment of this combination there is set loose from the blood a quantity of carbonic acid gas and water, in the form of vapour, which are thrown out with the air expired. This theory was adopted and illustrated by M. HASSENFRATZ, who succeeded in proving its superiority to that of LAVOISIER and his associates. The establishment of this theory depended upon proving that the oxygenous portion of the atmosphere alone is absorbed from the inspired air. This was indeed the generally received opinion of chemical philosophers for some time; but as it has lately been brought into question, and the contrary asserted, it is proper to notice the variation of theory which has thence been attempted to be made.

Mr. DAVY has endeavoured to prove that azote, as well as oxygen, is partly absorbed by the lungs in respiration. As the azote which disappears in breathing is not to be found in the products of respiration, it has been thence concluded that it is absorbed by the blood. The experiments of Mr. DAVY led him to believe that atmospheric air is absorbed by the blood in an undecomposed and unaltered state; that it is afterwards decomposed in that fluid by the affinity of the red particles for its oxygen; that the greater part of the azote is liberated without undergoing any change, and again given out and mixed with the air in expiration; but that a minute portion of it remains condensed in the serum and coagulable lymph, and passes with them to the left ventricle of the heart. A minute examination, and decision as to the correctness of these facts, will not be attempted in this place. But admitting the facts to be justly stated, the following changes will appear to be produced

by respiration. The blood in passing through the lungs absorbs a portion of air, and carries it along with it through the blood vessels. In the course of the circulation this air is gradually decomposed by the blood, the oxygen and part of the azote entering into new combinations, while at the same time a portion of azote, of carbonic acid and water, is evolved. On returning to the lungs, the blood receives a fresh quantity of air, and, at the same time, discharges the azotic gas, carbonic acid gas, and watery vapour which had been formed during the circulation. This theory of respiration by Mr. Davy is believed to be the latest of those deserving especial notice which belong to the eighteenth century.[b]

Besides the general theories of respiration which have been just stated, it will be proper to mention a few of the leading discoveries on this subject, and the authors to whom they respectively belong.

It was not till Dr. Priestley had discovered that venous blood acquires a scarlet colour when brought into contact with oxygen gas, and arterial blood a purplish red colour when put in contact with hydrogen gas; or, in other words, that oxygen gas instantly gives venous blood the colour of arterial, and that hydrogen, on the contrary, gives arterial blood the colour of venous;—it was not till the accomplishment of this discovery that philosophers began to attempt any explanation of the phenomena of respiration.

To Dr. Priestley likewise belongs the merit of that instructive experiment of enclosing blood in a bladder, and exhibiting the passage of oxygen through its moistened coats, by the florid colour thence imparted to the blood, in order to demon-

b *Researches Chemical and Philosophical*, by Humphry Davy, 8vo. 1800, p. 477, &c.

strate the mode in which oxygen finds its way through the coats of the blood-vessels in the lungs.

Dr. Goodwin was the author of the celebrated experiment, in which the action of the lungs is exhibited by opening the chest of a living dog, and exposing to view the motion of the lungs and heart. In this experiment, the blood driven from the right ventricle of the heart into the pulmonary artery, appears of a dark venous complexion; but on its return from the lungs, by the pulmonary veins, it is changed to a bright vermilion colour. He also demonstrated that the bright florid appearance of the blood, derived from oxygen received in the lungs, is absolutely necessary to enable it to stimulate the left ventricle of the heart, in order to produce the contraction which propels the blood into the aorta. For whenever an intermission in the motion of the lungs denied the access of air, the blood in the pulmonary veins returning to the heart was of a dark purple colour, and was no longer sufficient to excite the due contraction of that organ.

That respiration is the source of the *temperature* of animals, or of what is commonly called *animal heat*, is one of the results of the light recently thrown on that function. Physiologists long ago observed that animals which do not breathe have a temperature little higher than the medium in which they live. This is the case with fishes and many insects. Man, quadrupeds and birds, on the contrary, have a temperature considerably higher than the ordinary states of the atmosphere. It may be proved that the heat of all animals is proportional to the quantity of air they breathe in a given time. These circumstances are sufficient to establish the fact that the heat of animals depends upon respiration. On this subject the philosophical world are under strong obligations to Dr. Black, whose doctrine of *latent heat* offered the

first hints towards an explanation of the cause of temperature in breathing animals. It was observed, in a preceding chapter, that the discoveries of this eminent chemist place him in a high rank, and constitute much of the foundation of that chemical philosophy which is the boast of modern times, and the source of numberless improvements in the arts and sciences. He early perceived the light which his doctrine of latent heat was calculated to shed on the temperature of animals, and with great sagacity availed himself of the advantage.

Dr. Black formed the following theory of animal heat. He supposed part of the latent heat of the air received into the lungs to become sensible; that the temperature of that organ and of the blood passing through it is consequently raised; and that the blood, thus heated, communicates its temperature to the whole body. This opinion was plausible, but by no means free from objections; for admitting the truth of it, the heat of the body ought to be highest in the lungs, and thence gradually to abate in proceeding to the extremities; which is not the fact. The author's attempts to support this theory were so feeble as to induce the belief that he himself considered it as untenable.

Lavoisier first announced, in 1777, that animal heat was owing to the caloric disengaged from oxygen gas, during its decomposition and condensation in the lungs. Dr. Crawford, in 1779, adopted this opinion, and supported it by experiments. They both believed that all the changes produced by respiration are performed in the lungs; and their theory differs but little in reality from that of Dr. Black. They supposed the oxygen gas of the atmosphere to combine in the lungs with the hydrogen and carbon emitted by the blood; that, during this combination, the oxygen gas sets free a great quantity of caloric; and that

this caloric is not only sufficient to maintain the temperature of the body, but also to carry off the new formed water in the state of vapour, as well as the carbonic acid, and to raise considerably the temperature of the air expired. According to the opinion, therefore, of these philosophers, the whole of the caloric which supports the heat of the body is extricated in the lungs. But on this hypothesis the question will arise, how it happens that the heat of each individual is maintained nearly the same in every part of his body? To explain this, Dr. CRAWFORD endeavoured to prove, by well devised experiments, that the capacities for containing caloric in arterial and venous blood, are nearly as 11.5 to 10; that is to say, if it require a quantity of caloric, represented by 11.5, to heat a pound of arterial blood from zero to 30°. it will only require a quantity as 10, to heat a pound of venous blood from zero to 30°.

On these experiments the following conclusions were formed. Oxygen gas is decomposed in the lungs, in consequence of the affinity of the carbon and hydrogen of the blood for oxygen being greater than that of oxygen for caloric, or of the carbon and hydrogen for the blood. In proportion as the oxygen unites with the hydrogen and carbon, water and carbonic acid are formed; the caloric combines with the venous blood, which, in losing its carbon and hydrogen, becomes arterial, and has its capacity for containing caloric immediately augmented. The blood, now become arterial, in its circulation through the body, gradually absorbs carbon and hydrogen, repasses to the venous state, and sets free a portion of caloric in proportion as its capacity for containing it is diminished. According to this doctrine, therefore, the almost uniform temperature in all parts of the

body is owing to the gradual and successive changes of arterial blood to venous throughout the body, and of venous to arterial in the lungs. It is also agreeable to this doctrine to suppose that the higher temperature of some parts of the body may be caused by arterial blood absorbing more carbon and hydrogen, or, in other words, becoming more rapidly venous.

However ingenious this explanation deserves to be regarded, it has not been deemed satisfactory. The difference in specific caloric, admitting the calculation to be accurate, is justly thought too small to account for the great quantity of heat which must be evolved. And if the opinion of some be true, that the carbonic acid gas and water emitted in expiration are not formed in the lungs, but during the circulation, this doctrine must be altogether untenable.

This defect in Dr. Crawford's hypothesis might perhaps be remedied, if Mr. Davy's supposition of air entering the blood and combining with it in the state of gas, should be admitted. In that case it is evident that the air at first would only set free part of its caloric, and that the remainder must gradually escape in the successive stages of the circulation. In another mode, likewise, that defect has been attempted to be remedied. It has been alleged, that the evolution of caloric attends almost all chemical combinations; that all animal fluids which pass through capillary vessels and glands, for the purposes of secretion, are subjected to such new chemical combinations, as must incessantly give out heat; and that this glandular action thus accounts for the more general and copious source of animal temperature.

From the view of respiration now given, it results that the final causes of that function are these: 1. To complete the assimilation of the blood;

2. To produce and support animal heat: 3. To impart a quality to the circulating fluid which enables it to stimulate the left side of the heart.

After this account of respiration, which, from its great importance in the animal economy, has been treated of more at large than was at first intended, it is proper to proceed to the consideration of *Digestion.* This function in its full extent includes all the changes which aliment undergoes for the formation of chyle, whether such changes are effected in the mouth, stomach, or small intestines. But as it is the knowledge of the office of the stomach which has received the most important improvement within the period assigned for this retrospect, and as the other parts of the process, such as mastication, deglutition, the admixture of saliva, &c. were tolerably well understood before, it is obviously expedient to direct the chief attention to the former branch of the subject.

Galen supposed *heat* to be the principal cause of digestion, and this opinion so generally prevailed for a long time that the term *coction* was used by the greater part of physiologists instead of *digestion.* But, though the effect of heat in assisting and expediting digestion is universally admitted, no person will now contend that it is the sole cause.

During the eighteenth century, the theorists of digestion have ascribed it either, singly, to *fermentation*, *mechanical action*, or the *operation of a solvent* in the stomach; or to the combined effects of two or all of these agents.

Dr. Boerhaave, dissatisfied with the opinions of all who had gone before him on this subject, and leaning strongly to mechanical theory, admitted *fermentation* as one cause of digestion, but principally ascribed it to *trituration*, *pressure*, and powerful *quassation.* The analogy of digestion,

as performed in certain birds, seems to have led him into this doctrine. He had observed the *ostrich* to swallow pieces of iron and glass, evidently for the purpose of trituration, because the sound of *grinding* was perceptible to those who listened. In the *granivorous birds* he had noticed, in addition to the crop furnished with salivary glands to macerate and soften their food, a gizzard, or second stomach, provided with strong muscles to triturate the grain, and the eagerness with which they swallow gravel to assist the operation. Considering the predominance of mathematical doctrines at that period, it is not wonderful that this great mechanic in medical science was desirous to explain digestion on mechanical principles.

Early in the eighteenth century Mr. Cheselden appears to have imbibed some correct notions on this subject. He remarked, that in serpents, some birds, and several kinds of fishes, digestion seemed to be performed by *some unknown menstruum;* as he frequently found in their stomachs animals so totally digested, *before their form was destroyed*, that their very *bones* were rendered soft.

About the same time M. Reaumur instituted a set of experiments concerning this function; and, by a number of clear and decisive facts, exhibited in his excellent memoirs on this subject, proved the existence and agency of a solvent in the stomach.

About the year 1777, the Abbé Spallanzani, Professor of Natural History in the University of Pavia, began, by his numerous experiments and diversified inquiries, to throw new light upon the function of digestion. Having directed his inquiries to a great number of animals, man, quadrupeds, birds, fishes and amphibia, he was led to divide an extensive variety of stomachs, differing from one another in many important points of

structure and functions, into three classes, the *muscular*, *intermediate* and *membranous*.[c]

Among such as have *muscular* stomachs, he particularly examined common fowls, turkeys, ducks, geese, pigeons, &c. In these that organ is provided with very large and powerful muscles, capable of grinding down to powder the grains and other aliment which they receive. He proved by his experiments, that such muscular stomachs can pulverize pieces of glass, and abrade and smooth the rugged edges of the hardest substances, even of granite, without any injury to the animal. He resorted to experiments to illustrate the force of trituration in these stomachs, which a person of less ardour in this kind of investigation, and more tenderness for the animal creation, would certainly have spared. He caused a leaden ball, beset with needles fixed in it, with the points outwards, to be forced down the throat of a turkey. He contrived to make another swallow a ball of a still more formidable construction; for it was armed with small lancets, sharp at the points and edges, instead of needles: both balls were covered with paper, to prevent the throat of the animal from being hurt as they descended, but fixed so loosely as to fall off in the stomach. The consequences proved the force and ruggedness of these muscular stomachs; the needles and lancets were broken to pieces and voided without wounding or injuring the animal.

But notwithstanding such proofs of the strength and activity of this kind of stomach, he ascertained that the solvent powers of a *gastric liquor* are combined even in these animals with the operation of gastric muscles, to effect the process of digestion, and that they mutually assist each other.

c *Dissertations relative to the Natural History of Animals and Vegetables*, vol. i.

SPALLANZANI's next experiments were directed to animals possessing what he called *intermediate* stomachs; such as are endowed with muscles less thick and strong than the former, but more so than the *membranous* stomachs. Among these he examined and made experiments upon the raven, the crow, the heron, and many other birds, which have this intermediate structure of the organ in question. It was found in these birds, as might be expected, that digestion is performed by a more equal combination than in the former cases, of the forces of muscular action and a gastric menstruum secreted for the purpose.

These interesting experiments on digestion were finished with those animals which have thin *membranous* stomachs. This class comprehends an immense number of species, as man, quadrupeds, fishes, reptiles, &c. No triturating power is possessed by the stomachs of this description; for their muscular fibres seem to exert little other effect than that of propelling their contents through the pylorus. In proof of this is alleged the well known fact that cherries and grapes are often received and voided entire from the human alimentary canal. The solvent power of the gastric liquor, in these animals, was found almost solely to effect the dissolution of food, after the preparatory treatment of mastication, and the admixture of saliva. To prove the efficacy of this powerful agent in the process of digestion, SPALLANZANI enclosed different kinds of animal and vegetable food in linen bags, and in wooden tubes, perforated in such manner as to admit the entrance of the gastric juice; these he swallowed himself, and, after a short interval, the contents of them were found to be dissolved and discharged. He satisfied himself that no trituration could take place by employing tubes so thin and weak that the slightest pressure would

have crushed them to pieces; yet not one was ever broken, nor could he ever perceive the smallest depression or fissure. Of the active solvent powers of this gastric fluid he gives many remarkable proofs. In a dog it not only dissolved bones, but was found to corrode the enamel of two *dentes incisores* taken from the jaw of a sheep. And, from some experiments on himself, he observed it to be sufficiently powerful to digest not only muscular fibres and membranes, but tendon, cartilage, and even bone itself, when not of the hardest kind.

The conclusions arising from these experiments of the Professor of Pavia were, about the same time, confirmed and illustrated by others equally ingenious and interesting, undertaken by Dr. Edward Stevens.[d] He prevailed on a person to swallow little hollow spheres of silver, filled with food of different kinds; the sides of the spheres being perforated in various places, the gastric juice had access to, and, of course, could act upon their contents; and when voided, the food within them was found to be dissolved, either partially or entirely, according to the nature of it, and the time allowed for its remaining in the stomach.

The celebrated Mr. John Hunter is to be always enumerated among those who have improved our knowledge on the subject of digestion. In addition to many other improvements, he endeavoured to solve the question, how the stomach itself can remain unhurt, while it encloses so penetrating and active a solvent as the gastric juice, seeing that it consists of materials similar to a large proportion of our food? He ascribes to the *living principle* in animals the power which the stomach possesses to resist that action of its gastric fluid which penetrates and dissolves the aliment. In

d See his *Inaugural Dissertation*, published at Edinburgh, in the year 1777.

confirmation of this he observes, that intestinal worms can remain a considerable time unhurt in the stomach, while they retain the principle of life; but as soon as they lose this, they are dissolved and digested, like other substances. In like manner he asserts, that while the stomach itself retains this living principle, the gastric fluid cannot exert its solvent powers on it; but when the person dies, particularly in cases of violent and sudden death, that fluid immediately begins to corrode it, and sometimes is found to have made its way entirely through the coats of the stomach into the cavity of the abdomen.[e]

It seems, therefore, to result from all the most successful inquiries concerning digestion, made during the eighteenth century, that this function is variously performed by *mechanical action*, or *chemical solution*, in different animals, according to the structure of the stomach, and the nature of the gastric secretion; and that in man, and many other tribes of animals which possess similar organization of this viscus, it is effected by the solvent operation of the gastric fluid independently of trituration.

Besides the points in physiology already noticed, many others might be mentioned which have undoubtedly received much elucidation and improvement in the course of the late century. The senses of *Vision* and *Hearing*, which had previously derived a great deal of light from the endeavours used to investigate them, have been examined with still more minuteness and success within the last hundred years, and many new facts and principles concerning them have been satisfactorily ascertained. But the doctrines of *Secretion* and *Nutrition*, though so fundamental in a thorough acquaintance with

e *Phil. Trans.* vol. lxii. p. 447.

the animal economy, notwithstanding all the diligence and ingenuity bestowed on them by a multitude of physiologists, have not been cultivated with equal success, and indeed can scarcely be said to be better understood at this time than they were at the close of the seventeenth century.

The celebrated doctrine of the *Vitality of the blood*, which was first distinctly taught in modern times by HARVEY, found a new and able advocate in Mr. JOHN HUNTER, who maintained, in his lectures, that the *fluids* as well as the *solids* were possessed of the principle of life. The arguments by which he endeavoured to support this doctrine are not only ingenious and forcible in themselves; but they derive additional strength from the theory of respiration, and the principles of pneumatic chemistry, which are now generally received.

Within the period assigned to this retrospect, the functions and laws of the *Nervous System* have been investigated with the greatest zeal. WILLIS, in the seventeenth century, had laid the foundation of this improvement, by his accurate description of the brain and nerves. VIEUSSENS, in his *Neurographia*, pursued the subject with much discernment. Early in the eighteenth century HOFFMAN still further prosecuted this inquiry; and at a more advanced period of it, Dr. CULLEN exerted all his powers in the same course. The use made by the two latter of the knowledge gained on this subject, in constructing their medical theories, will be mentioned more particularly under the succeeding head.

Comparative physiology has been cultivated with great ardour and success in the course of the century now under contemplation. HALLER, though chiefly devoted to human physiology, did not neglect the instruction which may be derived from a

comparative view of the functions of man and other animals. The HUNTERS, the MONROS, and most of the other distinguished anatomists of the late century, laboured in this field with the utmost zeal and assiduity. The great anatomical work planned by VICQ-D'-AZYR, which was mentioned under the preceding head, was principally designed to deduce a body of physiological principles, which, by comparison, might illustrate the functions of the whole animal kingdom. The numerous comparative inquiries concerning animals of warm and cold blood, and those which, in respect of the function of generation, are distinguished into viviparous and oviparous, have already thrown much new and important light on this branch of knowledge, and opened a train of investigation which hereafter will probably lead to still more interesting results. Mr. BLUMENBACH, of Göettingen, whose physiological labours deserve very high praise, has greatly distinguished himself by his *Specimen Physiologiæ comparatæ inter animantia calidi sanguinis Vivipara et Ovipara.*[f] The recent work of M. CUVIER, on comparative anatomy, furnishes an abundance of the materials requisite for the extension and improvement of this part of science.

Within a few years the irritability of vegetables has attracted much of the attention of physiologists; and the interesting facts which it offers have been naturally combined with the great body of corresponding facts presented by the animal kingdom. Such general views penetrate deeply into the economy of nature, and the light they afford may be clearly discerned in an estimate of the progress and present state of medical opinions. To the account before given of the labours of

[f] Vide *Comment. Soc. Reg. Scient. Gotting.* vol. ix.

HALLER, in the former part of the century, to ascertain the fundamental laws of the animal economy, it would be improper not to add those lately undertaken for the same purpose by the Abbé FONTANA. By a series of experiments, in which accuracy and industry are eminently conspicuous, the Abbé has proved, beyond the possibility of doubt, the existence of a principle in the animal fibre, independent of nervous energy, from which result, on the application of certain exciting powers, the various actions suited to the support of animal life. This principle, which with HALLER he denominates *irritability*, has been since proved by a great variety of facts to be susceptible of two remarkable changes in the living fibre, viz. increase and diminution, depending upon the abstraction or accumulation of stimulant powers. In support of this general principle, which is supposed universally to belong to animated nature, the aid of many facts, derived from the vegetable kingdom, has been recently added. As the functions of the animal economy, viz. sensation and voluntary motion, to which the nerves seem alone to be necessary, are never satisfactorily observed in the vegetable kingdom, it is presumed that the absence of nerves in this kingdom can in no degree diminish the analogy which is attempted to be established between these two grand divisions of created nature. It is contended by these physiologists that there is a principle of action common to both kingdoms, upon which their respective functions chiefly depend, and which is believed to be governed by the same laws as are laid down for the regulation of the irritability of the animal fibre. By the term *irritability*, nothing more is here meant than merely to express a fact; which fact is this, that certain parts of animals and vegetables are possessed of a property, by which, upon

the application of a stimulus, the ends of a straight fibre approach nearer to each other, and the diameter or area of a curved or circular one is diminished.

For the facts respecting the functions of vegetables from which the above mentioned principles have been drawn, the world is indebted, among many others, to HALES, GREW, DUHAMEL, BONNET, BUFFON, SPALLANZANI, DES FONTAINES, GMELIN, INGENHOUZ, HUNTER, BROUSSONET, DARWIN, and many of the most distinguished disciples of the *Linnean* school. And when the progress made by them in vegetable physiology is considered in relation to the discoveries obtained by HALLER and FONTANA in animal physiology, it will not appear surprizing that inferences and doctrines of the greatest interest have recently been thence deduced. The physiological principles of BROWN and DARWIN, which now occupy the attention of so large a portion of the medical world, are conclusions resulting from that great body of facts. But of these more particular notice will be taken under the next head.

Theories of *Generation* have engaged much attention during the last century. Towards the close of the preceding one, LEUWENHOECK attracted notice by his microscopical inquiries concerning the *semen masculinum*, in which he believed that he saw numerous animalcula; one of which was destined to form the rudiments of the future embryo. This supposed discovery gave rise to a theory not yet altogether exploded, according to which the womb of the female only affords to the embryo a lodging, and the requisite supplies of nourishment.

M. BUFFON endeavoured to prove that the female holds a more important share in the process of generation. He asserts that animalcula, or or-

ganic particles, are to be found in the semen of both sexes; and he derives that of the female from the ovaria, denying, at the same time, that any ovum exists in those parts. But in this he is commonly supposed to be mistaken.

The opinion more generally adopted within a few years is, that an impregnation of the ovum by the influence of the semen masculinum is essential to conception. The Abbé SPALLANZANI has thrown much light on this obscure subject; he labours to prove, by a variety of experiments, that the animalcule exists entire in the female ovum, and that the male semen is only necessary to vivify and put it in motion.

This part of physiology furnishes one among numerous instances, in which modern improvements in science serve to support and confirm religious faith. It was mentioned, in the last chapter, that toward the close of the seventeenth century, the doctrine of *equivocal generation* began to be discarded by the ablest physiologists; still, however, it continued to find some advocates long after the beginning of the eighteenth. The *atheistical* tendency of this doctrine is obvious; for if a single animal could be produced in this manner, what should prevent the universe from having come into existence without an intelligent author? Accordingly this mode of accounting for the production of animals was, in general, fondly embraced by those who wished to exclude God from the creation and government of the world. But all the experiments and discoveries which were made, on the subject of generation, in the course of the century under review, have served to discredit this doctrine; so that it is now considered, by the most eminent naturalists, as exploded. It is true, difficulties, or rather darkness and doubt, still exist, particularly with respect to the genera-

tion of one class of animals; but all modern experiments seem to concur with analogy in showing, that the doctrine in question is unphilosophical and untenable. Indeed, it may be asserted that every successive step which has been taken in developing the structure and functions of the animal frame, and every new ray of light that has been shed upon this interesting subject, in modern times, have made more apparent the absurdity of atheism, and furnished new demonstration of the existence and wisdom of the GREAT FIRST CAUSE.

THEORY AND PRACTICE OF PHYSIC.

At the period of the revival of learning in the fifteenth century the medical system of GALEN was restored, and began generally to prevail. Early in the sixteenth century the famous PARACELSUS laid the foundation of a chemical system, which attracted much notice, and excited a violent contest with the followers of GALEN. The efficacy of the remedies employed by PARACELSUS and his disciples, and the bold and confident terms in which their virtues were extolled, procured, with many, the reception of his system, and for a long time supported its popularity and fame. But the regular and systematic physicians still generally maintained the doctrines of GALEN, and, by their superior learning, were enabled to keep possession of the schools of physic till the middle of the seventeenth century.

About this time the discovery of the *circulation of the blood* began to be generally received, which, together with that of the *receptacle of the chyle*, and the *thoracic duct*, gave a heavy blow to the Galenic theory. In the destruction of this theory, the operation of the revolution in philosophy, ef-

fected by Lord BACON, deserves likewise to be particularly mentioned. His method of philosophizing exhibited the futility of the numberless hypotheses which are found in the system of GALEN, and excited a disposition to observe facts and make experiments.

At the beginning of the seventeenth century the contest between the Galenical and Chemical physicians was carried on with the utmost animosity and indecorum. The influence of the writings of GALILEO, aided by the discovery of the circulation of the blood, introduced mathematical reasoning into the doctrines of medicine. The progress made about this time in the knowledge of the organic structure of animals, which was greatly facilitated by an acquaintance with the circulation of the blood, had extended the application of mechanical philosophy, in order to explain the phenomena of the animal economy. The agency of the nerves or moving powers of animals was, at that time, so little understood, that physicians universally, whether Galenists, Chemists, or Mathematicians, considered the state and condition of the fluids as the cause of diseases, and the medium of the operation of remedies. Hence arose the *Humoral Pathology*, which then predominated in every system of opinions, however diversified in other respects. While the followers of GALEN were daily losing ground from the circumstances which have just been stated, the Chemists gained some accession of strength from the doctrines of the humoral pathology. Chemical reasoning was readily adopted to explain the various acrimonies which were supposed to infest the circulating mass, and thereby to give origin to diseases. On this ground the use of stimulating, cordial and sudorific remedies became fashionable throughout Europe, in the latter half of the seventeenth cen-

tury. This doctrine, which exhibits the last glimmering of the chemical sect, attained its utmost height, and was taught and practised with the greatest applause by the celebrated FRANCIS DE LE BOE, more known by his Latin name of SYLVIUS, Professor of Medicine in the University of Leyden, who continued for many years the medical oracle of Europe, and gave an eminent degree of eclat to the seminary to which he belonged. With this physician *acidity* formed the principal source of morbid affections, and he extended and supported his doctrine by every analogy, that the learning of that period and the utmost ingenuity could devise. Agents adapted to correct or expel this acrimony were exalted into universal remedies, and supplied every intention of cure.

To oppose the *cardiac* and *alexipharmic* doctrines of the *Sylvian* school, which often consisted in doing violence to nature, and could not fail, when carried to extremes, of increasing the mischiefs it was intended to remove, required the powers of a great and original mind. For this purpose the illustrious SYDENHAM was eminently suited. The sagacity of this physician led him, by an almost seeming intuition, to discern and obey the dictates of nature, and to afford every proper assistance without urging her to useless and hazardous efforts. The effects of this revolution were immediately seen in the improved treatment of acute diseases of every class, when, instead of the fashionable alexipharmic remedies, intended to promote imaginary depurations, by additional heat and increased stimulus, a safer *antiphlogistic* or cooling plan was adopted, with a view to unload the oppressed habit, to reduce excessive action, and to preserve the strength of the system for the subsequent conflict.

Towards the close of the seventeenth century, the application of mathematical reasoning to me-

dical theory had attained its greatest height. The mathematicians were alike hostile to the Galenists and Chemists. With equal aversion they discarded the *qualities*, *elements*, *temperaments*, *concoctions* and *crises* of the Galenist; and the *Archæus* of VAN HELMONT, the *salts*, the *sulphur*, the *mercury*, the *acids*, *alkalies*, *effervescences*, *fermentations*, *ebullitions* and *deflagrations* of the Chemist. Instead of such objects as these, the mathematical pathologists endeavoured to direct the public attention to *mechanical tension* and *relaxation*, to *true* and *spurious plethora*, to *obstruction* and *error loci*, to *excessive* or *deficient motion of the fluids*, and to their *lentor*, *tenuity* or *dissolution*. Flushed with their success in astronomical inquiries, and with their dominion over the globe we inhabit, the Mathematicians confidently imagined they should find no difficulty in subjecting the province of medicine to their extensive empire. The Chemists of that day had little to urge against the claims of these invaders. Their loose, visionary and capricious doctrines (for such was undoubtedly much of the chemistry of that period) could make no successful opposition to the *axioms*, *postulates*, *propositions*, *lemmas*, *problems*, *theorems*, *demonstrations*, *corollaries*, and *calculations*, with which the mathematicians were constantly armed when they entered into controversy. BELLINI, of Florence, as was formerly observed, was among the first medical writers who introduced mechanical reasoning; and soon afterwards the application of it was extended still further by Professor BORELLI, who prosecuted the subject with great learning and zeal. The laborious calculations made by these mathematicians of the force exerted by the heart in propelling the blood,[g] and by the stomach in the di-

g BORELLI believed that he made it clearly to appear, that the force of the heart is equal to 180,000 *pounds* weight; while Dr. KEIL's calculation reduces the power of the left ventricle to *five ounces*.

gestion of food, are signal examples of the delusion which then occupied the most respectable minds. But no person at this period seems to have proceeded further in this course than the celebrated Dr. PITCAIRN, who, during some of the last years of the seventeenth century, held a medical professorship in the University of Leyden. He flattered himself that medical principles might be supported by a clear train of mathematical reasoning, which would defy the attacks of the sophist, and which would be exempt from the fluctuations of opinion and prejudice. His works are full of postulates, data and demonstrations. And, after a long parade of geometrical forms, he supposes himself to have arrived at the *ne plus ultra* of the science of medicine.[h]

The mechanic theory of medicine is now so obsolete that even the most illiterate affect to smile at the absurdities of that kind, which were often uttered by learned men. But it should be remembered that, amidst all its extravagance, it was an important step towards improvement; and it will certainly be rescued from contempt by the recollection that it was once honoured with the great names of BORELLI, BOERHAAVE and NEWTON.

The Italian and Dutch schools, though hurried into wild extremes by the rage of mathematical reasoning which then prevailed, possessed an unrivalled celebrity at the end of the seventeenth century. The history of medicine at that period particularly dwells on the merits and services of many of their physicians, and abundantly justifies their claim to distinction.

Thus stood the science of medicine at the be-

h PITCAIRN concludes his chapter, *De divisione Morborum*, thus triumphantly; "*Quapropter non dubito me solvisse nobile problema, quod est, dato morbo, invenire remedium. Jamque opus exegi.*" Vide *Elementa Medicinæ Physico-Mathematica*, p. 177. The annals of science can scarcely furnish a more striking example of the delusion of enthusiasm, or the blindness of prejudice.

ginning of the eighteenth century. At that auspicious period, every part of science began to assume a more correct and improved aspect, and, from the vast and diversified labours of the preceding age, it had become more practicable to select and combine the materials necessary to construct the theories of medicine which were speedily to appear. Accordingly, very early in the century three new and considerably different systems were presented to the world in the writings of STAHL, HOFFMAN, and BOERHAAVE. And they are the more worthy of examination at the present time, as they not only engrossed the attention of physicians during a great part of the century, but as even now they are not without influence upon principles and practice.

Notwithstanding the seniority of STAHL and HOFFMAN by a few years, they were, as theorists of medicine, strictly the cotemporaries of BOERHAAVE. It is judged expedient to begin with the latter in this place, not only on account of the great importance and celebrity of his system, but because his doctrines held a closer alliance with the predominant philosophy of that period, and those of the two others with the succeeding theories.

HERMAN BOERHAAVE began his career as a teacher and a writer, about the commencement of the eighteenth century. In all respects he deserves to be considered as one of the greatest men that ever adorned the medical profession. He possessed a vast range of erudition, and had cultivated the auxiliary branches of medicine with such assiduity, that he particularly excelled in anatomy, chemistry and botany. No physician, since GALEN, has so authoritatively swayed the empire of opinion, nor been more universally obeyed in the schools of physic. Endowed by nature

with a powerful, logical and systematic mind, he seemed to be designed to clear away the rubbish of error and prejudice with which he found medical learning overgrown, to collect knowledge from every source, and to present it to the world embodied in that clear, consistent, elegant and luminous state of arrangement, which constitutes him the parent of medical theory.[i]

In framing his system of physic, BOERHAAVE seems diligently to have studied the writings of both ancient and modern physicians, from HIPPOCRATES down to SYDENHAM. Though extremely partial to the mechanical principles of BELLINI and PITCAIRN, he appears to have endeavoured, as much as possible, to divest himself of prejudice in favour of former systems, and to make a candid and genuine selection of truth from every source. Besides availing himself of the experience of HIPPOCRATES, and other observers of nature in every age, he drew many of his doctrines from the chemical as well as mathematical philosophy of the period in which he lived.

i This great man was born at a village near Leyden, in the year 1668, and died in 1738. The space which he filled in the scientific world, for upwards of forty years, was so great, that no one acquainted with the history of the period in which he lived is ignorant of his immense learning, his singular talents, or his numerous and inestimable works. His moral and religious character is as worthy of commemoration as his intellectual endowments. "Some, though few," (says his great disciple, HALLER) will rival him in erudition; his divine temper, kind to all, beneficent to foes and adversaries, detracting from no man's merits, and binding by favours his daily opponents, may perhaps never be paralleled." He was at once a practical philosopher and an eminent christian. No one was ever less moved by the attacks of envy and malice; no one ever bore with more firmness and resignation the evils of life. Simplicity was the characterisic of his manners. He was easy and familiar in his converse; perfectly free from parade of every kind; grave and sober in demeanor, and yet disposed to pleasantry, and occasionally indulging in good humoured raillery. He was almost adored by his pupils, whose interests he regarded with the kindness of a parent, and whom, when sick, he attended preferably to any other patients. Piety of the most amiable cast, was wrought in the very habit of his soul; the perusal of the scriptures was one of his habitual and stated employments; and the business of every day was preceded by the devotional exercises of the closet. *General Biography* by JOHN AIKEN, M. D. and others, vol. ii.

Boerhaave's *Institutes*, which is his *theoretical* work, contain all the discoveries in anatomy and physiology known at that time; and that system likewise of pathology and therapeutics which he thought proper to adopt. His *Aphorisms*, or *practical* work, with all their imperfections, contain perhaps more medical learning than any book extant of the same size.

The most prominent feature in the *Boerhaavian* system is the attempt to explain the phenomena of the animal economy, whether in health or disease, upon mechanical principles. Under the impression of such opinions he considered the body chiefly as an hydraulic machine, composed of a conic, elastic, inflected canal, divided into similar less canals, all proceeding from the same trunk, which being at last collected into a retiform contexture, mutually open into each other, and send off two orders of vessels, lymphatics and veins, the former terminating in different cavities, the latter in the heart; that these tubes are destined for the conveyance of the animal fluids, in the circulation of which he supposed life to consist, and on the free and undisturbed motion of which he judged health to depend. He therefore believed *obstruction* to be the proximate cause of most diseases; and this obstruction he supposed to be produced either by a constriction of the vessels, or by a *lentor* in the blood.

In Boerhaave's doctrine of *obstruction*, which is fundamental in his system, he makes an important use of Leuwenhoeck's supposed discoveries concerning the blood. That eminent microscopical investigator had imagined that he found each globule of red blood composed of six serous globules, the serous of six lymphatic globules, the lymphatic of six other globules still finer, and so

on in a similar progression till these particles were diminished down to the finest and most subtile of all, namely, the nervous fluid. According to Boerhaave's opinion, the diameters of the vessels also decreased in the same regular series, perfectly corresponding with the size of the globules. This explains his frequent introduction of *error loci* in his account of obstruction and inflammation. But as the notions of Leuwenhoeck on this subject are now generally exploded, so likewise must be the inferences and doctrines grounded upon them.

It was taken for granted by Boerhaave, and by almost all preceding medical writers, that diseases always arise either from some depravity of the fluids, or some fault in the composition or cohesion of the simple solids; and that wherever such disorders exist, they are always susceptible of a definite character, and placed within the reach of the senses. He believed the fluids to be liable to contamination by acid and alkaline acrimony, and by other morbific matters variously constituted, and to be disordered by lentor and excessive tenuity. The simple solid, according to his doctrine, is subject to very frequent changes of condition, from weakness and excessive stiffness or elasticity, and from laxity and rigidity.

Boerhaave supposed the *proximate cause of fever* to consist in a lentor or viscidity prevailing in the mass of blood, and stagnating in the extreme vessels. To this he attributed the cold stage of fevers, and all its consequences. It is true that he afterwards introduced, though with some doubt and hesitation, as an additional part of the proximate cause, an *inertia* of that portion of the nervous fluid which is destined to the heart. It was one of his positions, that the morbid heat in fever, being a symptom only, might therefore be disregarded.

His doctrines of *acid* and *alkaline acrimony*, of *fermentation*, and of *morbific matter* in the blood, were evidently derived from the chemical theories which then prevailed. And from the mechanical philosophy he borrowed his opinions concerning the diseases of the simple solid; concerning deficient or excessive circulatory motion; concerning obstruction and *error loci*;[j] and concerning the *lentor* and morbid tenuity of the fluids.

The objections which have been made to this system are numerous and important. Though it was exhibited by the illustrious author in a very attractive and elegant form, and long possessed an unrivalled degree of reputation; yet it appears that time and the great mass of improvements since made in every department of medical knowledge have effected its entire overthrow.

The leading defects in the Boerhaavian system are too close an adherence to the humoral pathology, and a constant neglect of the moving powers of the animal body. In his notions of various acrimonies and of lentor he yielded almost entirely to a hypothetical mode of reasoning. In his consideration of the diseases of the solids, he dwelt too much on the changes of the simple inanimate solid, and too little on those of the living or vital solid. Most of the faults, however, of his theory are chargeable rather on the time in which he lived, and on the general imperfection of knowledge at that period, compared with the present, than on any defects in himself. It is surprizing that he considered his system as having advanced so near to perfection; for though he lived almost forty years after he had formed it, he seems to have made in all that time but few corrections or additions which can be thought to be of any moment.

j By this phrase is meant the entrance of particles of the blood into vessels whose capacity is too small to transmit them.

The next medical theorist whose system demands notice, is GEORGE ERNEST STAHL, Professor of Medicine at Halle, in Saxony, who was so illustriously distinguished for his improvements in Chemistry, mentioned in a former part of this work. For a long time this was the prevailing system in Germany; and the traces of it may be discerned in many modern writings, which still maintain a high degree of authority.

The fundamental principle of this system is that the *rational soul* of man presides over, and governs the whole economy of his body both in health and sickness. In all ages physicians have supposed the existence of a power or faculty in the animal economy, by which it is enabled to resist injuries, and to correct and remove the diseases to which it is exposed. This power, by many of the ancients, was vaguely termed *nature,* and under the denomination of *vis conservatrix et medicatrix naturæ,* has been long celebrated in the schools of medicine.

STAHL explicitly founds his system on the principle, that this *power of nature,* so much spoken of, is nothing else than a faculty of the rational soul.[k] On many occasions he imagines the soul to act independently of the state of the body; and that, without any physical necessity arising from a particular state, the soul, merely in consequence of its intelligence, perceiving the application of noxious powers, or the approach of disease from any cause, immediately excites such motions in the body as are suited to obviate the hurtful or perni-

k It appears that physicians are by no means unanimous in their mode of understanding the *Stahlian* theory. In proof of this the following quotation is offered from a writer of high reputation." STAHL has been reproached for having ascribed too much to the soul; but they who have done this, either have never read his works, or did not understand them. The soul, according to STAHL, is a being purely material; or rather he admitted no soul; only the vital principle of an organized body." ZIMMERMAN *on Experience*, vol. i. p. 93.

cious effects which might otherwise take place. He sometimes mentions two opposite principles or propensities in the human frame; one constantly and uniformly tending to corruption and decay, the other to life and health; the former founded on the elementary composition of the body, the latter depending immediately on the energy of the mind or soul. By means of the nerves, the influence of the soul is extended to every part of the system, and if their action be impeded or deranged, disease is the unavoidable consequence. A plethora and lentor of the blood is therefore the proximate cause of disease, as the energy of the mind is thereby diminished, and its action on the body obstructed. Hence, to lessen the quantity, and to break down the *lentor* of the blood, the soul exerts all its powers, and excites hæmorrhages, sweats, diarrhœas, fevers, and the like. These efforts are sometimes happy and successful; at other times they fail to answer the purpose, and may occasionally even do mischief, especially when opposed by the improper interference of physicians, or by some internal accidental or organic impediment.

Such is the theory of health and disease which STAHL delivered to his pupils and readers, and which he endeavoured to recommend and support by all his great powers of learning and ingenuity. But, in his ponderous volume on this subject, entitled *Theoria Medica Vera*, we look in vain for the logical arrangement, the elegance and perspicuity which are constantly displayed in the writings of BOERHAAVE. There were not wanting, however, in various parts of Europe, especially in Germany, many followers of STAHL, who thoroughly imbibed his principles, and pursued his practice in the treatment of diseases. Among these, JUNCKER and CARL, particularly the former, in his work, entitled *Conspectus Therapeiæ Specialis*, have given

a much better account than himself of the doctrines and opinions of their Preceptor.

To many, the *Stahlian* theory appears so fanciful and absurd, that they can scarcely think it deserving of a serious refutation. But still, it has been often thought there are such appearances of intelligence and design in the operations of the animal economy, that many eminent physicians have been induced to countenance similar opinions. Among these may be mentioned PERRAULT, in France; NICHOLS and MEAD, in England; PORTERFIELD and SIMSON, in Scotland; GAUBIUS, in Holland; and perhaps WHYTT, of the University of Edinburgh.

Of the writers who adopt the opinions of STAHL, in a greater or less degree, NICHOLS and GAUBIUS may be considered as two of those who deserve the highest consideration.[l] The consequences result-

[l] In an elegant prelection by Dr. NICHOLS, which he published under the title of *Oratio de Anima Medica*, we find the following visionary excesses of *Stahlianism*. According to him, the soul at first forms the body, and governs it ever afterwards. He ascribes it to the prudence of the soul, that the *semen* is not perfected in males, till the strength and vigour of the system are prepared for generation; and he sees her sagacity in the slow and gradual eruption of the small-pox, thereby dividing the force of the disease and greatly lessening the danger. After violent pain or exhaustion by fatigue, the soul hides herself in sleep, in order to recruit the body or to rectify any disorder; hence the inclination to sleep after child-birth; hence also the frequent sleeping of infants, whose *anima* is so engrossed with attention to the vital motions as to mind little else. When too much distracted and perplexed with external things, she often neglects her internal duties; and hence health is so much impaired by fear, grief, love and other violent passions. He also accuses the soul of occasional fits of caprice and ill-humour, by which she is led to disregard her office, and indulge herself in freaks of petulance and perverseness. In fevers, the sudden failing of the strength and pulse ought to be regarded, he tells us, as signs of the soul's abandoning the body in despair, and intending soon to relinquish it. Nay, he sometimes imputes to her cowardice and folly in suffering the body to sink under diseases by no means deadly in their own nature; in falling into undue alarm and trepidation, thereby becoming unfit to discharge her office, and being often precipitated into mischief and injury; and in deserting her post in a moment of peril, when, were she always wise enough to neglect things of inferior moment, and to attend solely to the preservation of the body, she might not only prevent diseases, so far at least as they proceed from internal causes, but might protract the life of man to an indefinite period, it may be, to a thousand years!! Vide *Oratio de Anima Medica*, passim.

ing from such doctrines may be discovered from what appears in their writings. If it be thought proper to admit such a capricious government of the animal economy as these writers in some instances maintain, it will follow that a rejection must take place of all the physical and mechanical reasoning which is employed concerning the human body.

Nor are the consequences of such doctrines confined to reasoning and speculation. It appears that STAHL and his followers, in the whole of their practice, whatever may have been asserted to the contrary, were very much governed by their general principles. Trusting to the wisdom and constant attention of nature, they proposed the *art of curing diseases by expectation.* As practitioners, therefore, they seem to have been cautious, indecisive and timid in the extreme; they adopted, for the most part, only very feeble, inert and frivolous remedies; and they strenuously opposed the use of some of those which are most efficacious and the most deserving of confidence.

It would be doing injustice, however, to the *Stahlian* practitioners not to acknowledge that they greatly enriched medical science, by their incessant and unwearied observation of the history and phenomena of diseases, and were instrumental in directing the attention of physicians to those salutary efforts of nature, which cannot be too accurately understood, nor too diligently pursued in the treatment of diseases.

FREDERICK HOFFMAN is the last of the three illustrious systematists whose different theories of medicine were disclosed to the world in the beginning of the eighteenth century. He was the colleague and rival of STAHL in the University of Halle, and a most learned and voluminous writer. For more than fifty years he flourished as a prac-

titioner and author, enjoyed a splendid reputation, and added greatly to the mass of medical science.

HOFFMAN had the discernment early to perceive the error of those who suffered themselves to be led away by the hypothetical doctrines of the *humoral pathology*, and the other wild opinions then prevailing among the chemical and mechanical theorists. He set himself to cultivate and improve what BOERHAAVE had neglected. He diligently undertook to explore the functions and diseases of the *nervous system*, and wisely concluded that noxious causes much more generally affect the *solid moving powers* than the *fluids* of the animal body. He admitted, indeed, into his system some portion of the mechanical, Cartesian and chemical doctrines which had previously prevailed; but these did not blind him to the light which he derived from the pathology of the nervous system. According to him, *atony* and *spasm* are the great sources of disease; and he proceeded so far as to maintain that all internal disorders are to be ascribed to some preternatural affection of the living solid.[m]

HOFFMAN's pathology of fever deservedly excited great attention. Though he undertook, like many of his predecessors, to inquire into the intentions of nature, he certainly contemplated her process in fever with more sagacity, and rejecting chemical and mechanical analogies on this subject, endeavoured to discover the cause of fever in the peculiar nature and affections of the vital motions. He supposed the noxious cause producing fever, (in the language of the schools, the remote cause) to operate first on the living solids, producing a general spasm of the nervous and fibrous system, beginning in the external parts, and proceeding

m Vide FRED. HOFFMAN. *Opera Omnia Physico-Medica*, vol. i. *Med. Rat. System.* tom. iii. § 1. cap. iv. p. 308. Geneva edition.

towards the center. In consequence of this, a contraction of the vessels of the extremities must of course take place, impelling the circulating fluids in an increased ratio on the heart and lungs; which stimulating these organs to increased action, the fluids are thereby repelled towards the extremities, and thus the phenomena of fever are produced. There are, therefore, according to HOFFMAN, two distinct sets of motions in fever; the first, from the extremities towards the center, arising immediately from the spasm, and accompanied by a small pulse, anxiety and oppression; the second, from the center towards the surface, which is the effort of nature to resolve the spasm, and indicated by a full strong pulse and increased heat. The first of these sets of motions is baneful, and sometimes fatal; the second is medicinal and salutary. By these views of the nature of fever, he supposes, the physician ought to be directed in counteracting the morbid actions, and in assisting the sanative process of nature."[n]

The general pathological doctrines of HOFFMAN undoubtedly contain a great deal of truth, and form a distinguished era in the history of medical theory. Though his opinions on the subject of fever, however improved by a succeeding theorist, must be supposed to be rapidly falling into disrepute; still they evince deep and just views of the animal economy, and much observation of the nature and phenomena of diseases.

The originality of HOFFMAN's scheme of pathology has been brought into question; and nobody can doubt that he received many important hints from preceding writers. VAN HELMONT seems to have been the first who turned his attention to the nervous system with any discernment. Some,

n HOFFMAN. *Op. Omn.* vol. i. tom. ii. p. 10.

indeed, have gone so far as to pronounce him the author of the *spasmodic theory of fever;* but whatever intimations he may be supposed to have given of febrile spasm in different parts of his huge indigested work, they are surely too crude and indistinct to be considered in the light of a theory of fever. Dr. WILLIS, in the latter part of the seventeenth century, had also laid some foundation for this doctrine, in his *Pathologia Cerebri et Nervorum;* and BAGLIVI, in the beginning of the eighteenth, had improved it still further in his *Specimen de Fibra Motrici et Morbosa.*[o]

The theory of diseases last stated formed the ground-work of a system which was adopted and taught for many years, with great celebrity, by the learned Dr. CULLEN, of Edinburgh. He assumed the general principle of HOFFMAN, that the phenomena of health and disease can only be explained by referring them to the state and affections of the primary moving powers of the animal economy. He endeavoured to extend the application and uses of this principle as far as possible; and for this purpose he expunged certain hypothetical doctrines of the humoral pathology, which HOFFMAN had suffered to remain, and to depreciate the value of his system.

According to the hypothesis embraced by Dr. CULLEN, the *brain*, with all its ramifications and dependencies combined to form the nervous system, is the primary organ of the human body, whose different conditions constitute the various states of health and disease. In pursuance of this hypothesis, the circulation of the blood, instead of being the principal of the vital functions, as in

o Dr. FERRIAR, of Manchester, in the preface to his *Medical Histories and Reflections*, makes the following remark: "The assertion of a spasmodic state of the extreme vessels in the cold stage of fevers, commonly ascribed to Dr. HOFFMAN, was first made by Dr. PIENS, in his comprehensive treatise *De Febre.*"

the Boerhaavian doctrine, occupies only a secondary degree of importance in the animal economy. Dr. CULLEN supposed it to be evident that the nervous power, in the whole as well as in the several parts of the nervous system, and particularly in the brain, which unites the several parts, and forms them into a whole, is at different times in different degrees of mobility and force. To these different states he applies the terms of *excitement* and *collapse*. To that state in which the mobility and force are sufficient for the ordinary exercise of the functions, or where these states are any way preternaturally increased, he gives the name of *excitement*; and to that state in which the mobility and force are not sufficient for the ordinary exercise of the functions, or when they are diminished from the state in which they had been before, he gives the name of *collapse*.[p]

Dr. CULLEN's opinions concerning the nature of fever have excited much attention and controversy in the medical world. He delivers an account of them in the following words: " Upon the whole, our doctrine of fever is explicitly this. The remote causes are certain sedative powers applied to the nervous system, which, diminishing the energy of the brain, thereby produce a debility in the whole of the functions, and particularly in the action of the extreme vessels. Such, however, is, at the same time, the nature of the animal economy, that this debility proves an indirect stimulus to the sanguiferous system; whence, by the intervention of the cold stage, and spasm connected with it, the action of the heart and larger arteries is increased, and continues so till it has had the effect of restoring the energy of the brain, of extending this energy to the extreme vessels, of re-

[p] See his *Institutes of Medicine*, § 126 to 135.

storing therefore their action, and thereby especially overcoming the spasm affecting them; upon the removing of which, the excretion of sweat, and other marks of the relaxation of excretories, take place."[q]

As HOFFMAN's theory of fever evidently produced that of CULLEN, it is proper to ascertain the points of variance between them. According to HOFFMAN, the first effect of the remote cause of fever is the spasm, producing a re-action, as has already been stated in the account given of his doctrine. CULLEN introduced a previous link into the chain of effects: he contended that the first effect of the noxious power (the remote cause) was a general debility, consisting in a diminution of the energy of the brain. To this debility he attributes the spasm, and to the spasm the re-action of the heart and arteries; which re-action continuing till the spasm is resolved, removes the debility and the disease. According to HOFFMAN, the spasm belongs to the class of motions which he pronounces to be baneful; but CULLEN presumes it to be salutary, and therefore ascribes it, in the language of the schools, to the *vis medicatrix naturæ*.

Dr. CULLEN's theory of fever was received with great applause, and, for a considerable time, maintained its ascendency, especially in the British dominions and in the United States. Few, however, at the present day, seem to consider it as tenable. The author has not undertaken to explain in what manner the debility in the whole of the functions proves an indirect stimulus to the sanguiferous system; nor how this stimulus operates in exciting the cold stage and spasm. The co-existence of atony and spasm in the same vessels

q *First Lines of the Practice of Physic*, vol. i. p. 55.

is regarded by many as an insuperable difficulty. No explanation is offered of the mode in which the action of the heart and larger arteries is augmented by the intervention of the cold stage and spasm. The process by which this augmentation restores the energy of the brain, and extends such energy to the extreme vessels, is also left entirely in the dark. His introduction of the *vis medicatrix naturæ* is liable to almost all the objections of the *anima medica* of STAHL, and must be considered as no better than a confession of ignorance. In all these respects, and many others, this celebrated doctrine rests on hypothetical ground. This will appear the more surprizing, as the learned author professed to disclaim all those hypothetical opinions which go to the formation of theories; and seems to have been persuaded that his doctrine of fever was only an induction from a generalization of facts.

It would be injustice, however, to Dr. CULLEN, not to subjoin that his merits are extensive and universally acknowledged. He was a diligent and faithful collector of facts. His works often contain admirable descriptions and sagacious discriminations of diseases. His great excellence seems to have consisted in methodical arrangement. But it is commonly remarked, and apparently with truth, that he was much more successful in demolishing the systems of others than in erecting his own.

The next system which demands attention, in the order of time, is that of Dr. JOHN BROWN, of Edinburgh. This original, eccentric, unfortunate man framed a physiological and pathological theory, which, amidst great errors, inconsistencies and contradictions, contains many vigorous conceptions of truth and nature, and some which it is

probable the improvements of future times will serve much further to elucidate and confirm.

Brown assumed, as the foundation of his system, the existence of an unknown principle, on which, when acted upon by stimuli, all the phenomena of life, health and disease depend, and which he denominated *excitability*. This excitability he believed to vary in different animals, and in the same animal at different times. As it is more intense, the animal is more susceptible of the action of exciting powers. Exciting powers, or stimuli, may be referred to two classes; either external, as heat, food, wine, poisons, contagions, the blood, secreted fluids and air; or internal, such as the functions of the body itself, muscular motion, thought, emotion and passion. Excitability produces no effect, or rather does not exist, unless exciting powers are applied; for if they are entirely withdrawn, death as certainly ensues as when excitability is consumed by the excessive application of them; life is therefore a *forced state*. Excitement may be, in just measure, too great or too small. Stimuli applied in due proportion produce that just degree of excitement which constitutes the state of health. If the stimuli are diminished below the healthy proportion, he supposed the excitability to accumulate; if increased beyond this proportion, to be expended; and on these opposite states he attempted to found a theory of diseases, denominating the former *direct*, the latter *indirect debility*. Diseases he divided into two classes, *Sthenic* and *Asthenic*, or such as arise from increased or diminished excitement. He believed no agent on the living body could properly receive the title of *sedative;* and insisted that every power that acts on such a body is stimulant, or produces excitement by expending excitability. Whatever powers therefore may be employed, and however

they may vary from such as are habitually applied to produce due excitement, they can only weaken the system by urging it into too much motion, or suffering it to sink into languor. He is supposed to have included both the nervous and muscular powers under the term of excitability; yet he did not consider the excitability as a property residing in and depending upon the mechanism of particular parts, but as an uniform, undivided property, pervading the whole system, which cannot be affected in any one without being affected in a similar manner in every other part.

Dr. Brown supposes the proximate cause of fever to consist in debility, which may be either direct or indirect, according to the nature of the noxious powers previously applied to the system. Hence he makes two divisions of fevers: 1st. Those which depend on direct debility, such as intermittent fevers, typhus, &c. 2d. Those which depend on indirect debility, such as malignant fever, confluent small-pox, plague, &c. Having therefore assigned to fever its place in his series of descending excitement, he neglected particularly to inquire into its symptoms, or to enlarge on its treatment. Thus debility, which was the first link in the chain of Dr. Cullen, formed, according to the theory of Dr. Brown, the essence of fever. He altogether denied the existence of spasm; he ridiculed re-action and the *vis medicatrix naturæ;* and he wholly overlooked the phenomena of morbid association and morbid heat.

In a word, the basis of Dr. Brown's system seems to be this; in whatever state of the body, whether healthy or diseased, there always exists either too strong or too weak an excitement. Hence there can be only two species of disease, two methods of treatment, and two kinds of medicinal agents.

In framing his system, Brown seems to have combined the *irritability* and *sensibility* of Haller to form his *excitability;* and to that eminent physiologist he was probably more indebted for the first hints of his doctrine, and especially for the facts on which it is founded, than to any preceding writer. His general principles are supposed more correctly to suit the condition of the animal economy in health than in disease. The fundamental position, that excitability is accumulated and expended in the inverse ratio of the stimulation, appears to be confirmed by many facts concerning the application of heat and the taking in of food, during the healthy states of the body, or when it is only affected by cold or hunger. Whether it equally holds good in the state of disease is more liable to doubt. He was acquainted with only one mode of action of the living principle, that which has been described by a succeeding theorist under the name of irritation; while he was wholly regardless of the influence of sensation, volition and association. He neglected, or was ignorant of most of the important relations which the doctrines of modern chemistry bear to the animal economy, and to the composition of animal matter. These, however, comprise only a small portion of the criticisms to which this system is exposed.

But with all these, and many more faults, it cannot be denied that the praise of genius and originality in an eminent degree belongs to Dr. Brown. The simplicity, comprehensiveness and consistency, as well as novelty, of his system, gave it a very seducing appearance, and contributed greatly to its prevalence. One of the greatest excellences of it, as applied not only to the practice of physic, but to the general conduct and preservation of health, is, that it impresses on the mind a

sense of the impropriety and danger of suddenly going from one extreme of excitement to another.[r]

Near the close of the eighteenth century, a new medical theory was presented to the world by Dr. ERASMUS DARWIN, in his celebrated work which he entitled *Zoonomia*.

According to this theory, there is, in every part of the animal system, a living principle, which is termed *Sensorial Power*, which is considered as the immediate cause of all its motions, and is supposed to be secreted in the brain and spinal marrow. This sensorial power is capable of being acted upon in four different ways, or it possesses, in other words, four different faculties or modes of action, which, in their passive state, are denominated *irritability*, *sensibility*, *voluntarity*, and *associability;* and in their active state, or during exertion, they are termed *irritation*, *sensation*, *volition*, and *association*. The faculty termed irritation is exerted, and produces fibrous motions in consequence of the stimulus of external bodies acting on any part of the system where sensorial power resides. That of sensation is exerted in consequence of the stimulus of pleasure or pain, occasioned by fibrous motions originally produced by the sensorial power of irritation. That of volition is exerted in consequence of the stimulus of desire or aversion, occasioned by fibrous motions, which had been previously produced by the sensorial power of sensation. That of association is at first exerted in consequence of the stimulus of fibrous motions, previously occasioned by irritation, sensation, or volition.

Having thus stated the various modes of action of the sensorial power, Dr. DARWIN proceeds to deliver the other fundamental principles of his theory.

r See BROWN's *Elements*, passim.

During the application of any of the above-mentioned stimuli, the sensorial power becomes exhausted; on the contrary, while any of them are withdrawn, it becomes accumulated.

In order to illustrate and establish his important doctrine of association, Dr. DARWIN asserts that there are various circles of associate motions in the animal system, which may take their names from that faculty of the sensorial power by which they are introduced. Those circles, for example, which are introduced by an irritative motion, may be termed irritative associate motions; and, in like manner, the sensitive and voluntary associate motions are produced and denominated. All these several circles of motions act on one another by means of the sensorial power of association; they may be affected by other sensorial motions, such as those of irritation, sensation and volition; and they may be considered as compounded, each one of smaller circles; as for instance, the great circle of irritative associate motions may be supposed to be made up of smaller circles of the same kind.

Conformably to this scheme of association, the introductory link of any circle of associate motions may have its action increased, diminished, or sustained in the natural degree. The first may take place either in consequence of excess of sensorial power, the stimuli being in their accustomed degree; or in consequence of excess of stimuli, the sensorial power being in its natural degree; or in consequence of excess of both. The second may arise either from want of sensorial power, the stimulus being in its usual degree; or, from subduction of stimuli, the sensorial power being in its natural quantity; or from want of sensorial power and subduction of stimuli. The third takes place, when both the sensorial power and the stimuli are in proper degree. In some cases, the morbidly in-

creased, as well as the morbidly diminished actions of the introductory link of a circle of associate motions are followed by similar actions of the other links; at other times, by contrary actions: In the former case there is *direct*, in the latter, *reverse* sympathy. The morbidly diminished actions arising from subduction of stimuli are sooner relieved than such as are occasioned by want of sensorial power. The morbidly increased actions which arise from excess of sensorial power are more violent than those which are produced by excess of stimuli. Hence inflammatory diseases are commonly preceded by subduction of stimuli, and consequent accumulation of sensorial power. But when excess of sensorial power is acted upon by excess of stimuli, the exertion which follows is far greater and more destructive. Hence the mortification of frozen limbs when brought near the fire.

According to Dr. DARWIN, all those parts which are subjected, during health, to perpetual action, as the heart and arteries, accumulate sensorial power faster when impeded, than those which are subjected only to intermitted action. When stimuli, which are usually applied to any particular part of the system, are withdrawn, an accumulation of sensorial power takes place there, proportioned to the subduction of those stimuli and to the state of that part.

The exertion of any part of the system, Dr. DARWIN believes, may be proper, or greater, or smaller than it ought to be. All diseases, therefore, originate in the exuberance, deficiency, or retrograde action, of the faculties of the sensorium, as their proximate cause; and consist in the disordered motions of the fibres of the body, as the proximate effect of the exertions of those disordered faculties. Hence, in conformity with the principles before mentioned, health, inflamma-

tion, and the various degrees of exhaustion of sensorial power, or torpor from accumulation of sensorial power, will be found to ensue.

After premising these general principles, and deducing from them many important doctrines concerning the sound and diseased states of the animal system, Dr. DARWIN proceeds to offer his theory of fever, which, whatever may have been the remote cause of it, he supposes *to consist in the increase or diminution of direct or reverse associated motions.* It commences in a particular organ, occupies one or more disordered tribes or trains of associate motions, and is more or less complicated according to the number of such disordered tribes.

Dr. DARWIN's doctrine of fever may therefore be considered as follows. When the torpor of any part of the system, owing to deficient irritation, occasioned either by the subduction of the natural stimuli, and consequent accumulation of sensorial power, or by the application of powerful stimuli and consequent exhaustion of the same living principle, is such as to occasion diminished action of that part, the following effects will take place: the next link of the tribe of associate motions falls also into a torpor, from defect of excitement of the sensorial power of association, and so the subsequent one, till a general torpor affects the system. This constitutes the cold paroxysm of fever. This general torpor remains till the accumulation of the sensorial power of association is formed, which overbalances that defect of excitement of association, and then the torpor ceases, and the hot fit of fever is produced. When the torpor of the part first affected is occasioned by the subduction of the natural stimuli, this is likewise thrown into increased action during the hot fit. But if it arise from exhaustion of sensorial power, the part remains in a torpid state during the hot fit. The torpor

induced by the subduction of natural stimuli, as it is overcome at the end of the cold fit, always gives rise to fevers of strong pulse; since, in such case, all the parts of the system have their actions increased during the hot fit. The torpor arising from the exhaustion of sensorial power produces various effects, according to the part in which it takes place. When seated in the stomach, it always produces continued fever, with weak pulse. In this case, in consequence of the torpid state of the stomach, the arterial system likewise falls into torpor, from defect of the excitement of association; therefore an accumulation of the sensorial power of association takes place in the arterial system. But this accumulation is so great, owing to the uninterrupted actions of the stomach, catenated with those of the arterial system, that it affects the next link of the associate train, that is, the capillaries of the skin, with increased energy. Hence these last, in this kind of fever, are perpetually exerted with great increase of action. When torpor affects the secerning vessels of the brain, it produces fever with arterial debility. In this case, the secretion of sensorial power being more or less impaired, languid actions of every part of the system must be the consequence. In fevers from this cause, the action of the capillaries is diminished with that of all the rest of the system. Hence the heat of the body does not rise above the natural standard, and sometimes it is even lower throughout the course of the disease; a phenomenon which serves to direct the attention to this cause. When torpor, from exhaustion of sensorial power, affects other parts of the system sympathetically associated with the stomach, such as the liver, spleen, &c. the stomach falls into torpor, from defect of the power of association, and, in like manner, the arterial system, till a general

torpor is formed, which constitutes the cold fit. During this cold fit, an accumulation of the associative sensorial power takes place in the stomach, arterial system, &c. which more than compensates this defect of excitement in the sensorial power of association; consequently all these parts are thrown into increased action. This constitutes the hot fit, which, according to the degree of accumulation of the sensorial power of association, and the force of stimuli applied to it, will produce various effects. Hence various kinds of intermittent fevers; or these increased actions may be in such degree as to produce sensation, and thereby occasion inflammatory fevers: or, lastly, such increased actions may, in consequence of their violence, produce a smaller, or greater, or complete exhaustion of sensorial power in some part essential to life. Hence various kinds of continued fevers with arterial debility, or even death.

On this extensive scale of sympathy and association, Dr. DARWIN endeavours to account for a great number of the phenomena of diseases, and especially for those of fever. From the same doctrine he deduces the indications of cure, and explains the operation of the remedies by which these indications are fulfilled.[s]

The extensive and accurate observations of the laws of organic life, the sagacious conjectures and profound reflections which abound in the *Zoonomia*, must be greatly admired. The most competent judges seem to concur in pronouncing it the ablest medical work of the eighteenth century. In col-

[s] The number of compartments which belong to the system of medical philosophy delivered in *Zoonomia*, the cycles and epi-cycles, and the variety and intricacy of the relations they bear to each other, render it difficult to comprize, within a short compass, such an abstract as can do justice to the ingenuity and learning of the celebrated author. If this attempt should be found unsuccessful, the difficulty of combining clearness and brevity in sketches of such a kind will not be forgotten.

lecting and arranging the facts belonging to animal life, and unfolding the influence of morbid association, which involves the essence of diseases, the author undoubtedly excels all preceding writers. Still, however, his work must be allowed to labour under great faults and radical deficiencies. In many instances he gives the rein to his imagination, and suffers fanciful speculations to usurp the place of facts and legitimate reasoning. His doctrine of the retrograde action of the absorbents, of which he makes such frequent and important use, in a great many various states of disease, may be mentioned as one of those which seem to want confirmation. And there is reason, indeed, to apprehend that errors still more fundamental and essential have crept into this vast plan for binding together the scattered facts of medical knowledge, and converging into one point of view the laws of animated nature. That interesting doctrine common to Dr. Brown and Dr. Darwin, that all the phenomena of life are to be explained on the principle of the excitability or sensorial power being accumulated and expended, in the inverse ratio of stimulation,[t] however elegantly it may admit of illustration by the use of heat, light and food, after coldness, darkness and hunger, seems to fail in its application to many morbid states of the system. It appears, on the contrary, often to happen that excitement and excitability are increased at the

[t] The originality of some of the leading doctrines delivered by Dr. Darwin has been called in question. He himself recognizes the coincidence of some of his opinions with those of Dr. Brown; but contends that he arrived at his conclusions on those subjects by a different train of reasoning from that of the Scottish theorist. He also declares, and asserts that his friends are able to attest the fact, that the greater part of his work had lain by him *twenty years* before its publication. These facts evidently preclude the probability of his being much, if at all, indebted to Dr. Brown. Dr. Hartley seems to have been the first who, clearly and with effect, employed the principle of *association* to account for the phenomena of the animal economy. (See *Observations on Man.*) It is not improbable that Dr. Darwin was indebted to him for some hints in forming his great work.

same time, and perhaps still oftener that they are diminished and wasted together.[v] The radical defect in every inquiry of this kind is our unacquaintance with the nature of the vital principle, a defect which the scantiness and imperfection of all human knowledge does not seem likely speedily to supply.

In a review of the systematic arrangements of medical knowledge, which have been undertaken in the course of the eighteenth century, it would be improper to pass without notice the learned and laborious work of M. LIEUTAUD, first Physician to the Monarch of France, published nearly fifty years ago, under the title of *Synopsis Universæ Medicinæ*. This singular work was attempted on the plan of collecting all the facts that experience has taught, without any reasoning concerning their causes. But the total want of method, perhaps the unavoidable result of the plan, continually introduced such confusion as to render this performance much less instructive and useful than might have been expected.

It may also appear improper to omit some notice of a theory of fevers, formed by the late Sir JOHN PRINGLE, which, from its peculiar character, has been denominated the *putrid theory*. Having been long conversant with the malignant diseases of camps and military hospitals, that respectable physician adopted the notion of miasmata and contagions operating like a ferment on the animal fluids, and thereby producing putrid fevers. This doctrine of fevers, however, is regarded as so vague and improbable that few have been induced to adopt it.

[v] The author is aware that Dr. DARWIN's theory makes provision to meet this difficulty and to explain it; but whether the explanation be sufficiently satisfactory, remains to be decided.

Among living authors, many have been so justly distinguished for their efforts to improve the theory and treatment of diseases, that it would be inexcusable to omit their names in this retrospect. Our learned and excellent countryman, Dr. Rush, stands in the first rank of medical theorists in the United States. His doctrine of the *proximate cause of fever* is the result of a long, vigilant and enlightened attention to the phenomena of febrile diseases, and to the various plans of cure which his extensive learning enabled him to survey. The pathology of the blood-vessels, which had been too much neglected by preceding theorists, seems to have employed a principal share of his attention in framing his doctrine of fevers; which makes their proximate cause consist of *a convulsion in the sanguiferous, but more particularly in the arterial system.* In conformity to this opinion, his decisive and energetic treatment of febrile diseases is chiefly directed to the reduction of excessive, and the liberation of oppressed action, by depletion, and other analogous means; or to the support of feeble action by appropriate stimulants; and afterwards to the transfer of remaining morbid action, of whatever kind, from the vascular system to parts less essential to life.[u]

The inquiries concerning the nature and constitution of *pestilential fluids*, which have been prosecuted with great learning and ingenuity by Dr. Mitchill, so radically concern many of the leading doctrines of diseases, that they may justly be said to embrace a new theory. His doctrine, as was before mentioned, is this, that the acid offspring of putrefaction, composed of oxygen and azote (which latter he denominates *septon*) chemically united, forms the febrile poison whose ravages are

u *Medical Inquiries and Observations*, vol. iv.

often so fatally experienced; and that alkaline and calcareous substances afford the best means of extinguishing its virulence. The evidence he adduces to maintain this doctrine, drawn from ancient as well as modern authorities, and from facts observed in all parts of the globe, does equal honour to his diligence and erudition.

In Germany there are several eminent physicians who lately have published systems of medical doctrines, which are said considerably to differ from all preceding ones, and which attract much attention in that enlightened part of Europe. Among these, the names of Reil, Roschlaub, and Hufeland deserve particularly to be mentioned; but the confinement of their opinions to the German language prevents them from being sufficiently known to give any account of them in this review.

Within a few years Dr. Reich, of that country, has presented to the public a new theory of fevers, which seems, however, to have attracted but little attention, and it is believed is now falling into neglect. His fundamental doctrine is, that fevers are produced by destruction of the equilibrium between oxygen and the other principles which enter into the composition of the animal body; and that fevers may be most speedily cured by introducing and restoring equally, to all parts of the body, such a quantity of oxygen as is necessary to re-establish the equilibrium between the different constituent parts. And hence he infers that acids, especially the mineral acids, and particularly the muriatic acid, are more adapted than any other remedies to the cure of fevers.

Among the improvements which occurred towards the close of the eighteenth century, *Pneumatic Medicine* holds a distinguished rank. The knowledge of the gases in the last quarter of the century assumed a regular and scientific form;

and the analysis of the atmosphere by SCHEELE and LAVOISIER, at that period, gave a new aspect to many doctrines of the animal economy, both in its healthy and diseased state. When the composition of the atmosphere, its influence in the function of respiration, and the constitution of animal matter, were ascertained, it was natural to suppose that many of the gases received into the lungs in breathing might become powerful remedies. M. FOURCROY took the lead in this inquiry, and was soon assisted by the exertions of Dr. GIRTANNER. Dr. BEDDOES was the first who introduced the pneumatic practice into Great-Britain, where it appears to have been more assiduously cultivated, and applied to a greater variety of medical purposes than in any other country. The names of DAVY, THORNTON, and TOWNSHEND are also to be mentioned among the most enterprising cultivators and improvers of this practice. The sanguine expectations of those who first proposed this mode of applying remedies seem hitherto scarcely to have been answered; but how far industry and ingenuity may hereafter vary and improve the practice, must be left to the decision of time.

The methodical arrangement of diseases, called *Nosology*, had its birth in the eighteenth century. This consists in a systematic distribution of diseases into classes, orders, genera, and species, on the plan of natural history. This scheme of arrangement was first conceived by SYDENHAM, and afterwards by BAGLIVI, towards the close of the seventeenth century. For the first actual attempt the world is indebted to FRANCOIS BOISSIER DE SAUVAGES, an eminent Professor of Medicine at Montpelier, who published his laborious work in the early part of the eighteenth century. After SAUVAGES, this subject was cultivated by LINNÆUS, to whose genius for arrangement every branch of

natural history is so greatly indebted; by RODOLPHUS AUGUSTUS VOGEL, of Goëttingen; by JOHN BAPTIST SAGAR, of Iglaw, in Moravia; by Dr. CULLEN, of Edinburgh; by Dr. MACBRIDE, of Dublin; and by Dr. DARWIN, in his Zoonomia; besides some others of inferior note. For some time past, the influence of Nosology has been evidently on the decline. The ever-varying forms of diseases are so dissimilar to the steady and fixed character of the objects belonging to the three kingdoms of nature, that it is difficult to account for the confidence and zeal with which this subject has been cultivated by some distinguished names. It cannot, however, be denied, that nosological inquiries have produced many good effects; they doubtless promote the discrimination of diseases; and many of the questions they involve are extremely interesting to the practical physician. An undue reliance upon nosology, and allowing it to substitute names for realities, seem to have produced the mischief which has thrown it into discredit.

The *cool regimen in fevers* constitutes one of the most universally acknowledged improvements in the practice of physic of the eighteenth century. A revolution on this point was begun by the new and interesting doctrines which the sagacity of SYDENHAM had enabled him to develope towards the latter part of the preceding age. Every day's additional experience gave some new confirmation of this important practice. A further acquaintance with the diseases of hot climates, where the pleasantness as well as the efficacy of coolness in fevers had overcome the opposition both of theory and prejudice, gave a deep blow to the alexipharmic and heating system. The good effects of coolness in the small-pox, and more especially in the improved stages of the inoculation of that dis-

case, seem to have settled the determination of physicians to extend the same remedy to the treatment of fevers. And the conviction since wrought by experience and observation, both on the public and medical mind, may now be said to have established this improvement on the firmest basis.

It is remarkable that although the use of cold air and cold water had been recommended in ardent fevers by HIPPOCRATES, GALEN, CELSUS, and most of the celebrated physicians of antiquity, as well as by many eminent moderns, it was discountenanced by BOERHAAVE and all the disciples of his school. In his commentator VAN SWIETEN, and in the writings of PRINGLE, CLEGHORN, LIND, and even CULLEN, little is to be found in commendation of this salutary practice. It remained for the learned and judicious Dr. CURRIE, of Liverpool, in Great-Britain, to extend the cool regimen in fevers, by adding to the use of cool air and cold drinks, the affusion of cold water over the surface of the body, when in a very dry and heated state. This remedy, the application of which, by long experience, he has been enabled precisely to regulate and determine, may be confidently pronounced to be one of the greatest of modern improvements in the practice of physic.[w]

In the course of the century under review, some particular diseases have been treated with more success than in former periods. It may not be improper to direct the attention of the reader to a few of the most remarkable of these.

The triumph of medicine over the *Small-Pox* has been completed in the eighteenth century. This scourge of the human race has exceeded all other diseases in the number of its victims, and in the

w See Dr. CURRIE's *Medical Reports on the Effects of Water, cold and warm, as a Remedy in Fever, and other Diseases.*

frequency of deformity, blindness, and other dreadful consequences inflicted on such as escaped with their lives.

The practice of *Inoculation* has reduced this frightful malady to such a degree of mildness and safety that it no longer excites the terror of the community. The date of this interesting discovery is lost in the obscurity of tradition and immemorial usage. Traces of it may be found among the traditions of many former ages in Great-Britain, particularly in Wales and the Highlands of Scotland, in Italy, France, Germany, Denmark, Sweden, and some other parts of Europe, in Africa and Asia, particularly in Hindostan and China.*

But the eighteenth century may boast of the first regular and satisfactory notices of this noble improvement, and of making it to be understood and practised in an intelligent manner among all the enlightened part of mankind. It is generally said that the *Circassians* first inoculated their children in order to rear them as slaves for the Turkish Se-

* It is a remarkable fact, that, in all the countries above mentioned, there is satisfactory evidence of inoculation for the small-pox having been practised by the common people, for many years before its introduction by the physicians of Great-Britain; and, in some of them, as far back as tradition can be traced. It is also a still more remarkable fact, that in *Wales*, in the Highlands of *Scotland*, among the ignorant peasantry of *Germany*, in the interior of *Africa*, and in several parts of the *Asiatic* Continent, distant as they are from each other, differing widely as they do, in manners, customs, laws and religion, the art of communicating this disease by inoculation was designated by the singular phrase of *buying the small-pox;* because it was superstitiously imagined that inoculation would not produce the proper effect, unless the person from whom the variolous matter was taken received a piece of money, or some article in exchange for it. See Dr. WOODVILLE's *History of Inoculation.* How shall we account for so many different and distant nations agreeing in so remarkable a phrase to express inoculation, and agreeing also to connect with it such a superstitious ceremony? How shall we account, further, for this art being confined chiefly to the *common people*, or the less civilized part of mankind, while the learned were ignorant of it? May it not be admitted as one proof of the *great antiquity* of the practice, that precisely that portion of the community, whose habits, in every country, are in general most simple, uniform, and stationary, were found to retain a practice which the more polished had lost?

raglio; and it was certainly first introduced into *Constantinople*, from *Georgia*, towards the end of the preceding age. From Constantinople the British nation received an account of the practice of it by the celebrated Lady M. W. MONTAGUE, who caused the disease to be thus communicated to her own children. In 1721, inoculation was first regularly adopted in England; and in the succeeding year, the operation being performed upon some of the children of the Royal family, it soon began to be in vogue. Objections both of a physical, moral and religious kind were urged against this new practice, with great zeal and intemperance, by many respectable persons of the medical and clerical professions, as well as by others of inferior character. These objections, for some time, excited scruples in the minds of many well-disposed people, and greatly retarded the progress of inoculation. Having at length, however, surmounted these difficulties, the value of the discovery became every day more highly rated, and before the middle of the century might be considered as established upon the firmest basis.

In the year 1721, and in the same month in which the daughter of Lady MONTAGUE was inoculated in England, this mode of communicating the small-pox was introduced at Boston, in Massachusetts. Dr. COTTON MATHER, one of the Ministers of that town, having observed, in a volume of the *Philosophical Transactions*, printed in London, some communications from Constantinople and Smyrna, giving a favourable account of the practice, and the small-pox beginning, about the same time, to spread in the town, he recommended to the physicians of his acquaintance to make trial of inoculation. They all declined it excepting Dr. BOYLSTON. He began with his own children and servants. But the degree of odium

which he drew upon himself by this measure is scarcely credible. The physicians in general highly disapproved his conduct. Dr. DOUGLASS,[y] one of their number, who had received a regular medical education in Scotland, his native country, stood foremost in the ranks of opposition. He wrote, declaimed, and employed all his influence against the intrepid innovator. The medical gentlemen were joined by the populace, who were so much inflamed against what they esteemed a species of murder, that Dr. BOYLSTON was in danger of his life,[z] and Dr. MATHER was scarcely less an object of popular indignation. But the greater proportion of the Clergy of Boston embarked in support of the measure; they preached and wrote[a] in favour of it, until, at length, their influence, greatly confirmed by the success attending Dr. BOYLSTON's practice, gradually overcame the opposition; and near three hundred persons were soon after inoculated in Boston and the neighbouring towns.[b]

y Dr. DOUGLASS is said to have been a man of learning and talents. He published some small medical pieces, and corresponded with Dr. COLDEN, of New-York, who, in one of his medical communications, speaks of him in terms of high respect. He was, however, conceited and arrogant, and behaved with great disingenuousness in his opposition to BOYLSTON.

z Dr. BOYLSTON's house was attacked with so much violence, that he and his family did not consider themselves safe in it. He was assaulted in the streets, loaded with every species of abuse, and execrated as a murderer. Indeed, many sober, pious people were deliberately of opinion, when he commenced the practice of inoculation, that if any of his patients should die, he ought to be capitally punished. A bill was brought into the Legislature for prohibiting the practice, under severe penalties, and actually passed the House of Representatives; but some doubts existing in the Council, its progress was arrested, and it never became a law. See HUTCHINSON's *History of Massachusetts*, vol. ii. p. 247, &c.

a The *newspapers* teemed with pieces on both sides of this interesting controversy; and especially with some of a very virulent character, from the opponents of inoculation. The *Courant*, a newspaper edited at that time by a brother of Dr. BENJAMIN FRANKLIN, took a decided part with DOUGLASS and his coadjutors. The young philosopher was then an apprentice in the office, and employed his opening talents in favour of the same deluded party. *M. S. Letter of the Rev. Dr.* ELIOT *to the Author.*

b HUTCHINSON's *History of Massachusetts*, vol. ii.

A degree of the same prejudice and opposition, which raged with so much violence in Boston, continued to be manifested not only there, but also in many other places, for a considerable time afterwards. But the practice gradually gained ground, and became general in New-England; in a few years it was adopted in New-York and Philadelphia; and in the year 1738 had reached Charleston, in South-Carolina.

Till near the close of the century now under consideration, the inoculation of the small-pox continued more and more to prevail, and to become the settled habit of all that portion of society who were placed in easy circumstances, and possessed the better degrees of intelligence. The advantages, however, of this practice, notwithstanding all its benefits to the individuals who employed it, were supposed by many, on a general calculation of human life, to be extremely problematical. By carrying the disease more frequently and universally through cities and countries, it was found that the poorer classes of people, which constitute the great mass of every nation, were much oftener exposed to casual infection; and that, on the whole, the mortality of mankind from this disease was thereby much augmented.

But such doubts and difficulties as these arising in the mind of the philanthropist, and much of the importance of the inoculation of the small-pox, even to those who employed it, were removed by the discovery of the inoculation of the *Vaccine Disease*, in the year 1798. This may perhaps be justly considered as the most memorable improvement ever made in the practice of physic. By substituting a disease so much milder that it cannot fail of being universally preferred, and one which at the same time affords effectual security against the small-pox, the prospect is presented of speedily

exterminating the latter disease, and thereby closing a great outlet of human life.

To Dr. JENNER, of Great-Britain, the world is indebted for this incomparable discovery. For although there has existed, perhaps from time immemorial, some popular knowledge of the vaccine disease, and of the fact of its rendering the human system unsusceptible of the small-pox;[c] yet the practice of inoculating it successively from one person to another as a substitute for the small-pox, and the investigation of the principal circumstances which ought to regulate that inoculation, in order to confer upon it the greatest certainty and success, seem undoubtedly to have originated with that physician. Further investigations and discoveries have since been made, concerning the nature and the inoculation of this disease, by other physicians, particularly by Drs. PEARSON and WOODVILLE, and Mr. RING, of London.[d]

All preceding ages, and a considerable portion of the eighteenth century, abound in accounts of

c For a number of years before Dr. JENNER's discovery, it was known to many, physicians as well as others, that a disease existed among the cattle in Great-Britain, particularly in Gloucestershire, which it *was said*, among the common people, when communicated to the human subject, formed a defence against *Small-Pox*. Dr. BARRY tells us that this disease has been long known in Ireland, under the name of *Shinach;* he gives instances of persons who had passed through it *fifty years* ago; and mentions that one woman, *eighty years* of age, declares, that as long as she can remember, the opinion prevailed, that people who had the *Shinach*, or *Cow-Pox*, could not take the *Small-Pox;* and that many, at that early period, purposely exposed themselves to the former, to avoid taking the latter. Traces have also been found of some knowledge of this disease existing in other parts of Europe, among the lower classes of people, a number of years before the publication of Dr. JENNER. See BARRY on *Cow-Pox*.

d An institution in Great-Britain, for the purpose of preserving and communicating the *vaccine* infection, and particularly for inoculating the poor, has been formed since the publication of Dr. JENNER's discovery. For this the public are principally indebted to the enlightened and benevolent exertions of Dr. PEARSON, of London. A similar institution has been more recently formed in the city of New-York. The first person who inoculated with the vaccine virus, in the United States, was Dr. WATERHOUSE, Professor of the Theory and Practice of Physic in the University of Cambridge, Massachusetts.

the destructiveness of the *Scurvy* in ships on long voyages, in armies, particularly in garrisons, as well as in some regions of the high latitudes. Towards the close of the period under examination, that dreadful disease has been disarmed of all its violence, and seems now to be completely reduced under the dominion of the healing art. This revolution has been effected by procuring for persons in the situations above mentioned more comfortable shelter, cloathing and food. Fresh meats substituted for salted, and vegetables plentifully supplied, especially the vegetable acids, may be considered among the principal means of prevention and cure. The *citric acid*, in particular, has accomplished wonders in this disease; and the late discovery of crystallizing it renders the remedy conveniently portable to any distance, and capable of preservation in all climates and seasons, and for any length of time. The eminent services of Dr. LIND in improving our knowledge of this disease can never be forgotten. The philosophic and enterprising Captain COOK was the first who reduced the improvements in nautical medicine to practice, in all their extent, and with complete success.[e]

Pestilential diseases are supposed to have greatly abated in frequency and malignity in the course of the eighteenth century. This observation, how-

e In the first voyage for the establishment of the East-India Company, out of four hundred and eighty men one hundred and five died of *scurvy* before they reached the Cape of Good Hope. Lord ANSON, in his voyage round the world, lost, from the same disorder, four-fifths of his original number. Those who have read the narrative of his expedition, by ROBINS, will recollect the dreadful picture which is drawn of the ravages of this disease, in the vessels under his command. Captain COOK, thirty years after ANSON, with a company of one hundred and eighteen men, performed a voyage of three years and eighteen days, throughout all the climates, from 52 deg. north, to 72 deg. south, with the loss of only one man, who had been previously indisposed. See Dr. RAMSAY's learned and interesting *Review of the Improvements, Progress and State of Medicine in the Eighteenth Century*, &c. p. 28 and 30.

ever, must be understood to be chiefly restricted to those parts of the world which, during that period, have been making progress in civilization, intelligence and refinement. In many parts of Asia and Africa, and in European Turkey, it is probable that little abatement of the ravages of such diseases has actually taken place. The degraded state of man in most of the Mahometan countries; the poverty, filth and wretchedness which oppress the lower classes of people in their crowded cities, and the inattention to cleanliness and ventilation, even in the houses of the most opulent, aided by the influence of their doctrine of fatalism, seem to leave them little prospect of emerging from their present condition into one more respectable, and exempt from malignant diseases. The contrast of health and disease, in the Christian and Mahometan world, while it affords to the pious mind a satisfactory confirmation of his faith, furnishes also, to the philosopher and physician, an instructive lesson, with regard to the comparative influence of the respective principles and institutions of Christianity and Mahometanism.

The comparative mildness and infrequency of pestilential diseases in Christian Europe, during the late century, are probably owing to a combination of many causes. Much may be safely ascribed to improvements in the cleanliness and ventilation of houses, in diet, in apparel, in habits, customs, and all the modes of life. Cities, which are usually the great nurseries of pestilence, are now less crowded than in former ages. The comforts, decencies, and elegances of life, from a variety of causes, are now enjoyed by a greater portion of the community, and in a much higher degree than in preceding times. To the same causes, also, may be ascribed the almost entire banish-

ment of that loathsome disease the *Leprosy*, from the civilized world, which has been in a great measure effected in the course of the last age.

The frequent and mortal prevalence of the pestilential disease called *Yellow Fever*, in the cities, and in some parts of the country, in the United States, for the last ten years, forms a memorable event in the medical history of this country, during the century which is the subject of this retrospect. The malignity and ravages of this epidemic impressed the public mind with the deepest apprehensions, and undoubtedly gave a new impulse and vigour to medical investigation. The origin of this disease has been warmly contested in the United States, in the West-Indies, and in Europe. While many maintain that it is produced by the exhalations of putrefaction, whether such putrefaction be found in the filth of cities, of marshy grounds, or of vessels on the water; others, on the contrary, assert, that it is always produced by contagion emitted from the sick labouring under the disease, and successively propagated from one person to another. The latter opinion seems to be fast losing ground among the better informed part of the medical profession, and of the public; while the evidence in support of the former is accumulated, and rendered more luminous and irresistible, by the occurrences of every epidemic season. Much light has been thrown on the origin, course, precursors, and concomitant circumstances of this, and of other pestilential diseases, by Mr. Noah Webster, in his *History of Epidemics*, an ingenious and learned work, in which a rich and curious amount of information on this subject is brought together and exhibited in a very impressive manner. Though the author is no physician, he has made a most valuable present to the medical world, and has entered and pursued with much

ability a path of inquiry, which will probably conduct to very interesting and instructive conclusions. In the mean time, the modes of treating yellow fever have received great improvement, during the period under consideration. Those who have written on this disease with most reputation, are Dr. RUSH, of the United States, who has had ample experience in the treatment of it,[f] and Drs. JACKSON and CHISHOLM, of Great-Britain.

The diseases of *Camps*, *Armies*, and *Military Hospitals* have attracted much attention, and the treatment of them received great improvements in the course of the late century. The means of preventing diseases, in such situations, are much more attended to than formerly; particularly all circumstances which respect the sites of encampments, the shelter, cloathing, food, cleanliness, &c. of troops, and the ventilation of the places in which they are stationed. For many of these improvements the public are indebted to Sir JOHN PRINGLE, Drs. DONALD MONRO, BROCKLESBY, HUNTER, and others, who have written on the diseases of armies. The means of preventing and curing the diseases incident to *Seamen* have also been more diligently and successfully studied in the course of the last age than ever before. For very enlightened inquiries and useful publications on this subject we owe much to Drs. LIND, MACBRIDE, CLARKE, BLANE and TROTTER.

f The intrepidity and benevolence displayed by Dr. RUSH, during the several seasons in which pestilence has prevailed in Philadelphia, deserve the highest eulogium. This remark applies with peculiar force to the season of 1793, when the yellow fever appeared in that city, arrayed in greater terror than ever before or since, in any part of the United States; when the methods of treatment were comparatively little understood; when it was universally considered as an highly contagious disease; and when the fortitude and services of this distinguished physician, through the whole course of the epidemic, were pre-eminently conspicuous. If the admirers of moral heroism celebrate, as they justly do, the conduct of the good *Bishop of Marseilles*, and of the benevolent *Lord Mayor of London*, it is conceived that the firmness and useful exertions of Dr. RUSH, in similar circumstances, are, in no respect, less worthy of their commemoration and praise.

Modern times have also given rise to improved modes of preserving the health, and promoting the comfort of persons confined in *Prisons*, and other close apartments. The honour due to the Rev. Dr. HALES, and Sir JOHN PRINGLE, for their philosophic inquiries, and enterprising exertions to forward this branch of improvement, are generally known. But to no individual that ever lived is the cause of humanity more indebted for services of this kind, than to the immortal HOWARD, whose long and painful journies, persevering labours, and successful plans for meliorating the condition of *Prisoners*, in every part of the world, to which he could obtain access, will ever form one of the most honourable pages in the annals of human nature.[g]

The diseases of *Warm Climates* are become better understood, by the efforts of modern times to extend the range of geographical and commercial enterprise; and, from their bold and definite features, much light has been thrown on the theory and treatment of such as prevail in more *temperate* regions. In fact, the whole of that important and interesting field of inquiry which relates to the comparative frequency and force of particular diseases, as they appear in different regions of the earth, and in different states of society, had been but little explored prior to the period which we are now considering.

The exertions recently made to investigate the nature and causes, and to lessen the fatality of *Pulmonary Consumption*, deserve a transient notice.

g In JOHN HOWARD the eighteenth century may boast of having produced an UNIQUE IN THE HISTORY OF MAN. It would be unjust to compare him with any hero of benevolence, merely human, before or since his time, for such an one never existed. It has been truly said, that his plan for promoting the happiness of his fellow creatures was *original;* and that it was as full of *genius* as of *humanity*. That it was the RELIGION OF CHRIST which directed and animated the exertions of this wonderful man, no one can doubt who is acquainted with his history and character.

If such exertions have not yet produced all the good consequences which humanity could wish, there is yet ground to believe they have effected some good, and that no effort in such a cause will be finally lost. Justice requires, whenever this subject is mentioned, that the philanthropic labours of RUSH and BEDDOES should be duly appreciated. Similar exertions have also been made, and with like considerable success, to throw light on the nature and cure of *Scrophula,* and the *Diseases of the Mind,* to say nothing of many others equally worthy of notice.

Under this head it is proper to take some notice of the successful attempts which have been made, during the eighteenth century, to enable the *Deaf* and *Dumb* to *speak*. Deafness has, in all ages, been considered such a total obstruction to speech, and the knowledge of written language, that the attempt to teach those who are destitute of the sense of hearing, either to speak or read, has been generally regarded as vain. This continued to be the case till after the middle of the century under review. Dr. JOHN WALLIS, towards the close of the preceding age, had, indeed, suggested in his *Grammatica Linguæ Anglicanæ,* a plan for conveying ideas to the minds of the deaf, more distinctly than by ordinary signs. His attempt was succeeded by those of his countrymen BAKER and HOLDER, each of whom devised a plan, and made some progress in its execution. To these may be added some other attempts, attended with partial success, by HELMONT, an ingenious German, and AMMAN, a Swiss physician. There was, however, little done to any valuable purpose, till the year 1764, when Mr. THOMAS BRAIDWOOD, of Edinburgh, undertook the difficult task. In that year he began with a single pupil, when, his exertions being attended with complete success, he was

encouraged to extend his views, and afterwards taught a considerable number to speak distinctly, to read and write, and to understand arithmetic, and the principles of morality and religion. The same curious and highly interesting art has also been practised, on a different plan, but with great success, by M. HEINECKE, of Leipsic; and by Father VANIER, M. PERRIERE, and the Abbé L'EPEE, of Paris. The last named gentleman has been more successful than any other. He had instructed upwards of *one thousand* deaf and dumb persons, before he was succeeded by his pupil M. SICARD. A regular institution for this kind of instruction was established in London, in 1792, under the care of Mr. WATSON, a pupil of Mr. BRAIDWOOD.

The late century has likewise made great progress in ascertaining the means of *restoring the suspended actions of life. Humane Societies*, for the recovery of drowned persons, which began to be instituted soon after the middle of the century, have since been multiplied to such extent, that they are to be found in most great sea-port towns. Great exertions have been made to improve the knowledge formerly possessed on this subject; and the means now employed are much more rational and successful than the rude and often pernicious ones which used to be resorted to. Many efforts have likewise been made to prevent the premature interment of such as are only apparently dead; by which some valuable lives have been saved, and more caution relative to this point impressed on the community. The service rendered by many physicians to the cause of humanity, by promoting objects of this kind, deserves honourable commemoration. Of these perhaps few are entitled to a larger tribute of acknowledgment than Drs. HAWES and LETTSOM, of London.

It would be easy to descend to a great variety of particulars, in which the means of curing, or mitigating diseases, have been radically improved, during the period under consideration; but the limits of this retrospect forbid such details. It is sufficient to remark, that a large portion of diseases, however faithfully observed by preceding, and even by the most ancient physicians, have, within this period, been better understood, arranged, and discriminated than ever before; and that remedies of superior efficacy have been selected, their qualities, virtues, and uses more fully ascertained, and the best mode of their application rendered more definite and precise. The number of incurable diseases, also, has been diminished, and the treatment of many hazardous and violent ones so far improved as greatly to diminish their force and danger. The recent doctrines of *Association* and *Sympathy* in morbid action, and the interesting practical doctrine which results from them, of the *transfer of morbid action* from vital parts to such as are less essential to life, have unfolded a vast extent of medical exertion and usefulness, which was nearly unknown to the physicians of former centuries.

The *practical writers* on medicine, during the eighteenth century, were very numerous and respectable. From so large a catalogue it is difficult to select the few names of which the brevity of this review will allow the insertion. Besides a considerable number of those mentioned in the foregoing pages, WINTRINGHAM and HUXHAM, on epidemical diseases, deserve a high place; CLEGHORN, on the diseases of Minorca; HILLARY, WHYTT, FOTHERGILL,[h] HEBERDEN, LIND, JACK-

[h] Dr. FOTHERGILL died in 1780, in the 68th year of his age. Distinguished as he was for his learning, the solidity of his talents, and the extent and success of his medical practice; he was rendered still more con-

SON, FORDYCE and CHISHOLM do honour to the British nation. Among the French SENAC and LIEUTAUD, and among the Germans STORCK and DE HAEN hold the first rank; to say nothing of many others, in almost every cultivated part of Europe, who have obtained much distinction by their practical writings on medicine.

SURGERY AND OBSTETRICKS.

That department of medicine which treats of diseases to be cured or alleviated by the hand, by instruments, or by external applications, is denominated Surgery. At the close of the seventeenth century this art had considerably emerged from the low state in which all preceding ages had left it. Many respectable writers had appeared in the course of that century, whose exertions to improve the practice of surgery, and to diffuse the knowledge of such improvements, were attended with so much success as to render the progress of it comparatively rapid at the commencement of the eighteenth century.

It will be easy to perceive that the numerous improvements in other branches of medicine, which are detailed in the preceding parts of this chapter, must have greatly advanced the progress of surgery. Every step in the cultivation of anatomy and the theory and practice of physic confers some advantage on medical or operative surgery.

spicuous by the purity of his moral and religious character, and the ardour of his philanthropy. His great influence was continually exerted for the increase of human happiness. Of every institution within his reach, which had for its object the advancement of useful knowledge, or the interests of humanity, he was a zealous and active promoter. Of public and private charity he was an illustrious example; and we are informed, that a large number of those improvements which have so much contributed to the health of the city of London, either originated from his counsels, or were effected, in a great measure, by his influence.

The improved state of the mechanic arts has likewise served to divest it of much of that useless machinery with which it was formerly encumbered, to retain only what appears to rest on the basis of experience, and to aid ingenuity in supplying many important deficiencies. Hence, the surgery of the eighteenth century may not only boast a more intimate acquaintance with the structure and functions of the human body, and with the fundamental principles of diseases, but likewise a superior simplicity, neatness, ease and expedition in the performance of operations.

Early in the century which forms the subject of this retrospect, LAURENCE HEISTER, Professor of Surgery in the University of Helmstadt, published his system of surgery, which continued till about fifteen years ago to be the only tolerably complete system in possession of the public. This work comprised whatever the experience of former times had approved as useful, and such observations and precepts as the knowledge and experience of the learned author himself enabled him to add. Some other systematic arrangements of chirurgical knowledge were, indeed, attempted about the middle of the century. PLATNER, Professor of Surgery at Leipsic, published his institutes of surgery in the year 1745; and LUDWIG, of the same University, favoured the world with a similar publication in 1767. But both these works, though possessed of great merit, are too compendious to give a clear and distinct account of the numerous topics of which they treat.

In Great-Britain, Mr. CHESELDEN was much distinguished by his chirurgical eminence in the early part of the century. He improved the lateral operation of *Lithotomy*, and devoted much attention to the diseases of the *Eyes*. His pupil, Mr. SAMUEL SHARPE, obtained soon afterwards a high

reputation. His *Treatise on the Operations of Surgery*, and his *Critical Inquiry*, were deservedly considered as performances of great value at that period. The elder MONRO, of the University of Edinburgh, deserves also to be mentioned among those who did much to improve the practice of surgery about that time. Towards the middle of the century Dr. WILLIAM HUNTER, of London, began to acquire great celebrity as an anatomist and surgeon, and was joined not long afterwards by his brother, Mr. JOHN HUNTER, who, as an operator, was still more distinguished. To the exertions of these eminent men the art is indebted for many valuable improvements, both in theory and practice. After the middle of the century Mr. PERCIVALL POTT began to take a high station among British surgeons, added greatly to the progress of the art, and published many excellent writings, which are still in the highest esteem. The present Professor MONRO, of Edinburgh, has enriched surgery by many important additions to the preceding stock of knowledge, which greatly increase the lustre of his reputation. Late in the century, about the year 1788, Mr. BENJAMIN BELL, of Edinburgh, completed his *System of Surgery*, which was compiled with much learning and diligence, and exhibited an advantageous view of the progress and improvements in surgery up to that period.

The particular improvements in surgery during the late century are extremely important, and reflect great credit on the ingenuity and labours of those by whom they were made; but they are likewise so numerous that only a few of them can be mentioned consistently with the necessary brevity of this retrospect.

The means of putting a stop to *Hæmorrhagies*, from the division of the larger blood-vessels, have

been much improved during the period under consideration. The first notices of the instrument for this purpose, called the *Tourniquet*, originated in the seventeenth century. It is amazing that so simple an instrument, and so obvious a means of compressing arteries, should have remained unknown till that period. Surgery must have been in a deplorable state of rudeness and imbecility when no operation of importance could be undertaken on any of the extremities but with the greatest danger of bleeding to death, and large wounds, otherwise in no degree hazardous, must often have proved mortal for the want of this simple contrivance. The first attempts to construct it were very rude and imperfect; and it was reserved for Mons. PETIT, of Paris, by adding the screw, to render it much more convenient and powerful in the compression of arteries. Another interesting improvement in securing arteries belongs to the late century. Instead of the *needle* and *ligature*, which were formerly used for this purpose after operations, the *tenaculum*, or *forceps*, is now employed, which produces much less pain, and prevents many ill consequences of the old method. The first application of the needle and ligature to surgical purposes, which is ascribed to AMBROSE PAREY, of the sixteenth century, was a great improvement. Since that time many variations have taken place in the mode of using them; and in the course of the eighteenth century, the different kinds of *Sutures* have been still further improved in many important respects.

The treatment of diseases of the *Head* from external violence has been extremely improved within the period of this retrospect. For this interesting part of the progress of surgery the world is much indebted to M. LE DRAN, Mr. POTT, Mr. BROMFIELD, and others.

The various species of *Herniæ* are much better understood within the last fifty years; and much of the progress in this branch of surgery is due to the acuteness and indefatigable labours of the late Mr. Pott. The disease termed *Hydrocele* has also, within the same period, been investigated with much more success than ever before; for this much is to be ascribed to Mr. Pott, Mr. Benjamin Bell, and Sir James Earle.

The interesting subject of *Aneurisms* has derived great additional light from the researches of modern anatomists and surgeons. Dr. William Hunter examined the phenomena of this disease with great diligence and success. The present treatment of the *popliteal aneurism*, which forms a memorable improvement in surgery, is to be ascribed to Mr. John Hunter.

The lateral operation of *Lithotomy*, which is now generally preferred, owes much of its present improved state to the labours of the surgeons of the late century. Mr. Cheselden did a great deal to improve it in the first half of the century; and, since his time, much has been done by Pott, Bromfield, Gooch, Sir James Earle, and many others. The *Gorget*, which is so important among the several instruments employed in this operation, was the invention of Mr. Hawkins, of London.

In the management of *Fractures* and *Luxations* much advantage has been obtained, within the last fifty years, by avoiding the constrained and unnatural positions formerly imposed in such cases, and generally placing the affected limbs in that easy, relaxed and bent position which the natural inclination of the patient prompts him to assume. By this means much pain is spared, and the straightness and perfect recovery of the affected limbs exceedingly promoted. The efforts of Mr. Pott in

effecting this salutary reform deserve very honourable mention.

The treatment of *Gunshot Wounds* is another point on which the surgery of the eighteenth century claims a great deal of improvement. This has been chiefly effected by giving up the artificial and over-officious management of former times, by admitting the operation of general principles, instead of considering them as poisoned wounds, and by adopting the light, easy and superficial dressings which experience has been found to approve.

Much light, during the late century, has been thrown on the various diseases of the *Eyes*, and particularly on the *Cataract*. The same may be observed of *Fistula Lachrymalis*, and of *Fistula in Ano*. Among many others, Mr. POTT has largely contributed to the elucidation of all these subjects, and to the banishment of many prejudices and errors concerning them, which fifty years ago existed in great force. To the same distinguished practitioner surgery is indebted for a mode of treating *Curvatures of the Spine*, far more successful than any previously known.

Lately Mr. ABERNETHY, of London, has suggested a mode of treating *Lumbar Abscess*, which sometimes succeeds very happily, and often affords reasonable grounds of hope in that deplorable disease. And not long since, the theory and management of *Ulcers* has been greatly improved by the persevering labours of many surgeons, among whom it would be unjust not to mention Mr. BENJAMIN BELL, Mr. HOME, Mr. BAYNTON, Mr. WHATELEY, and Mr. NAYLER. The subject of *Wounds* has recently been treated with great ability and discernment by Mr. JOHN BELL, of Edinburgh, who deservedly sustains a high rank among the surgeons of the Scottish metropolis.

But the greatest of all improvements in surgery which the eighteenth century can boast, consists in the maxim of *Saving Skin* in all operations, and in the universal doctrine and practice of *Adhesion*, as now received. This improvement is so simple and so important that it is wonderful to find it reserved for the surgeons of so late a period. The merit of this discovery does not seem to belong exclusively to any individual. A share of it doubtless attaches to Mr. ALANSON, of Liverpool, in Great-Britain, and several others who directed their inquiries to this object about the same time. But to Mr. JOHN HUNTER more is certainly due than to any other person. This improvement was first applied to *amputation*, then to the operation of the *trepan*, next to the extirpation of schirrous mammæ, afterwards to all the great operations, and, lastly, to all recent wounds. In short, it would not be too much to assert, that this doctrine and practice of *adhesion* has done more to promote the progress of surgery, within a few years, than any discovery of modern times, not excepting, perhaps, even that of the circulation of the blood.

It remains to offer a few remarks concerning the progress of *Obstetricks* in the late century. By this term it is usual now to understand not only the art of facilitating the birth of children, but that of managing pregnant and puerperal women. During the period of our retrospect, the improvements which this art has received may justly be considered as numerous and important, and fully equal to those which are claimed in the other departments of medicine.

Both the theory and practice of obstetricks have assumed a much more regular and scientific form within the period in question. The anatomical structure of the body, so far as it concerns this art, was well understood in former ages. But the in-

tricate and interesting relations of one part to another, their distances and their inclinations, both with respect to each other, and to different parts of the body, as well as with regard to the fœtus, form a branch of inquiry on this subject which has been prosecuted to advantage only in modern times. Dr. SMELLIE, of Great-Britain, is supposed to deserve the praise of beginning this improvement and pursuing it to considerable extent.[m]

By the light of the eighteenth century, not only many new truths have been brought into view, but a multitude of errors, prejudices and superstitious opinions, which formerly misled the obstetrical art, have been in a great measure banished.[n] Nature has resumed its dominion, and is now followed as the safest guide. Much of the officious and violent interposition of former practitioners, to hasten or controul the natural process of parturition, has been found to be injurious, and is now generally relinquished. The modern instruments, in comparison of those employed by the ancients, are few in number, simple in construction, and seldom resorted to.

The diseases of the puerperal state have been much better understood, discriminated and treated within a few years, than in preceding times. The late publications of Dr. SMELLIE, Dr. MANNING, Dr. HULME, Dr. LEAK, Mr. WHITE, Mr. MOSS, Dr. HAMILTON, Dr. DENMAN, Dr. OSBORN, M.

m Dr. SMELLIE is said to have been the first writer who considered the shape and size of the female pelvis, as adapted to the head of the fœtus; and to have abolished many superstitious notions, and erroneous customs, that prevailed in the management of women in labour, and of children; and to have had the satisfaction to see the most of his maxims adopted in the greater part of Europe. RAMSAY's *Review*, p. 13.

n VAN SWIETEN quotes several authors of reputation, who had advised lying-in women to keep their beds till the tenth or twelfth day after parturition; and this was frequently done without changing their bed-linen. The children were also incased from head to foot, so as to be totally deprived of the use of their limbs. These absurd and unnatural practices have, within the last half century, been gradually exploded. *Ibid.*

Baudelocque, and many others, whose names are only excluded by the brevity of our plan, have thrown much light on the subject of obstetricks, and do great credit to their profession. The elegant plates of Dr. William Hunter, before mentioned, may also be considered as a great acquisition to the theory and practice of this art.

MATERIA MEDICA.

The knowledge of the nomenclature, the methodical arrangement, and especially of the virtues of those substances which are employed either for nutriment or the cure of diseases, must be considered as forming a very important branch of medicine. Accordingly it has received much of the attention of physicians in all ages. But in no period of equal length have inquiries on this subject been pursued with so much accuracy and success, or the discoveries and improvements been so numerous, as during the century under review. Many new articles, in this period, have been added to the former catalogues; the properties of articles formerly known and employed have become better understood than before; the application of old remedies greatly extended; and the whole subject made to wear a more scientific aspect.

From the account which has been already given of the state of the other branches of medicine, at the close of the seventeenth century, the reader will readily perceive that materia medica, so closely connected with them, in its principles and application, must have been, at the same period, in a corresponding situation; perhaps it may even be said to have been less cultivated at that time than any other branch of medical science. But soon after the commencement of the eighteenth

century the views of medical philosophers began to be much more correct and enlarged on this, as well as many other subjects belonging to the healing art. About this time the *cardinal qualities*, and other jargon of the Galenists; the *distilled waters, essences, quintessences* and *extracts* of the chemists; and many of the wild opinions respecting the application and efficacy of remedies, which resulted from mathematical and mechanical doctrines, began to decline; while new light, from various quarters, directed to more rational methods of experimenting and philosophizing on the subject.

The improvements which were made in the science of *Botany*, in the course of the last age, proved the source of many important additions to the materia medica. New plants of great medicinal value were brought from every part of the globe. Vegetables were examined, and their properties ascertained by means of more numerous, patient and enlightened experiments than preceding naturalists had attempted. The service rendered, particularly to this branch of the materia medica, by CHOMEL and GEOFFROY, of France; by VOGEL, of Germany; by LINNÆUS, and his pupil BERGIUS, of Sweden; and by ALSTON, WITHERING, WOODVILLE, and others, of Great-Britain, are generally known. All these writers have treated of plants, with a special reference to their medical uses, and the greater number of them have delivered formal systems. But besides what was effected by their inquiries, our knowledge of the subject has perhaps been still more increased by many of the other illustrious botanists mentioned in the preceding chapter. For while these latter have laboured to distinguish plants from one another, and to present them in a convenient method, few of them have failed to pay some attention to their

medicinal virtues, and in many instances to make very interesting experiments of their effects on the human body.

The improvements in *Mineralogy*, during the period under review, have also furnished many new articles, and extended our knowledge of others in the materia medica. The eminent services rendered to medicine in this way, by SCHEELE, BERGMAN, KLAPROTH, VAUQUELIN, and a large number of other distinguished mineralogists, are so generally known, that it is unnecessary to enlarge on the subject.

While the progress of natural history has contributed greatly to the enlargement and correction of the materia medica, the discoveries and improvements in *Chemistry* have served still more eminently to promote the same end. When the employment of chemical remedies first became an object of much attention, in the hands of PARACELSUS and his followers, it was attended with so much error, and embraced so many visionary and absurd opinions, as rather to corrupt and degrade medical science, than illustrate its principles, or guide their application. And, indeed, till the close of the seventeenth century, the doctrines of the chemist, when applied to medicine, served little other purpose than to amuse and mislead. But modern chemistry, in every respect a more just, rational, and dignified science than what had been called by that name in the preceding age, has opened resources for the materia medica of incalculable value; and is daily furnishing the enlightened physician with some of the most efficacious means of preserving health and combating disease.

The chemical inquiries of the eighteenth century have brought to light many new medicines, some of which hold the first rank for convenience, cheap-

ness, and efficacy. From the same source physicians have learned to reject many inert and useless substances which formerly held a place in the materia medica. They have been taught, also, by chemistry, greater accuracy in forming their preparations, more easy, efficacious, and correct methods of exhibiting different substances, and more definite rules for adapting remedies to diseases. To enumerate those who have distinguished themselves by contributing to the improvement of the materia medica, through the medium of chemical investigations, would be to repeat the long catalogue of great chemists before given, whose names do so much honour to the last age.

Several systematic writers on the materia medica have been already mentioned. To these might be added a much greater number, who have written learnedly and extensively on the subject, did not the limits of this review forbid such an enumeration. It would be improper, however, not to take some notice of what has been done in this department of medical philosophy by LIEUTAUD, FERREIN, and especially by VENEL, of France; by CARTHEUSER, SPIELMAN, and MURRAY, of Germany; and by HILL, LEWIS, ALSTON, CULLEN, and DARWIN, of Great-Britain. Of these the work of Dr. LEWIS, improved by Dr. AIKEN; that of Professor CULLEN; and particularly the *Apparatus Medicaminum* of Professor MURRAY, of Goëttingen (the most extensive, learned, and complete of all), are entitled to the largest share of esteem.

The late work of Professor BARTON, on the materia medica of the United States,[o] forms a

[o] *Collections for an Essay towards a Materia Medica of the United States*, 8vo. 1798. Under this modest title, Dr. BARTON has presented a body of information, and discovered an accuracy and extent of learning, which might, without impropriety, have made higher claims. It is pleasing to observe that this work is so favourably received by the author's countrymen, that a *second edition* was lately demanded, into which he has introduced considerable additions and improvements.

very valuable addition to the knowledge before possessed on this subject, and reflects high honour on its learned author. From the extent of information, the vigour of mind, and the ardent zeal by which this American naturalist and physician is distinguished, we may hope for further investigations, and richer discoveries of the medical treasures of our country.

Though it is impossible to enumerate all, or even the greater part of the new articles with which the materia medica has been enriched, in modern times, it may not be improper to take some notice of a few of the most celebrated and useful.

The first application of *Electricity* to medical purposes belongs exclusively to the eighteenth century. It was before observed that Mr. Kratzenstein, of Germany, was the first person who applied the electric fluid to the cure of diseases, and that the course of experiment and inquiry on this subject was further pursued by the Abbé Nollet, and by many others, at later periods. After correcting numerous errors arising from the extravagant calculations of the first experimenters on medical electricity, there remains no doubt of its efficacy in many diseases of nervous derangement and muscular debility; so that it is now fully established as an article of the materia medica.

Within a few years past, an agent, which is probably nearly allied to electricity, and which is denominated *Galvanism*, or the *Galvanic Fluid*, has become a popular application in certain diseases. The original discovery, together with the progress and gradual extension of this branch of philosophy, was mentioned in a former chapter. That this wonderful agent possesses great efficacy in many cases similar to those in which electricity is found to afford relief, seems to be too well attested to admit of doubt; but the extent of its application,

the rules which ought to regulate it, and the degree and permanency of relief which it is capable of affording, have been so imperfectly investigated, that it is difficult to speak with precision or certainty on the subject.

The introduction of *Factitious Airs* into the materia medica may be considered as marking a splendid and very interesting period in its history. Some facts on this subject were stated in a preceding section, to which it will only be added, that though our knowledge of this important class of remedies is yet in its infancy, there are probably few sources from which more important aid to the physician may be expected to be hereafter derived.

The affusion of *Water*, cold and warm, on the body, in fevers and other diseases, deserves to be mentioned in this place as a new article in the materia medica, at least with respect to the principles and manner of its application. The simplicity, pleasantness, universal readiness of access, and unquestionable efficacy of this remedy, will, it is to be hoped, soon recommend it to general use. The honour due to Dr. Currie, of Liverpool, for his enlightened experiments, and valuable publication on this subject, was before noticed.

The efficacy and uses of *Peruvian Bark* have been better understood, within the last century, than in any former period. Its free and successful exhibition by modern physicians, in *intermittent fevers*, in *scrophula*, in cases of *gangrene* and *mortification*, and in numerous diseases of *relaxation* and *debility*, is well known. To the exertions of Sir Hans Sloane and others, in introducing this medicine into general use in Great-Britain, much honour is due.

The use of *Mercury* has also been greatly extended, and its effects more accurately observed, during the century under review. The introduc-

tion of this metal as a remedy in a multitude of diseases,[p] and especially in malignant fevers, may be considered as a memorable event in the annals of medicine. Those who have most distinguished themselves by recommending the use of mercurial preparations in the latter class of diseases, are Drs. RUSH and CHISHOLM.

The great extension of the use of *Opium* in the eighteenth century deserves particular notice; but the principles of this extension, and the variety of cases in which it has been lately employed, are too numerous to be detailed.

Digitalis has long held a place in the materia medica; but its efficacy in certain diseases, particularly in *dropsy* and *pulmonary consumption*, has been clearly known but a few years. For much information respecting the virtues of this powerful vegetable, we are indebted to the publications of Drs. WITHERING, BEDDOES, and others.

The use of *Lead*, particularly in various external applications, has been better understood, and more frequently employed, within the last half century, than before. Those who have been most distinguished by their inquiries into the medical virtues of this substance are M. GOULARD, of France, and Dr. AIKEN, of Great-Britain.

Many of the best preparations of *Antimony* now employed by physicians, were either wholly unknown, or little used, prior to the eighteenth century. The important station they now hold in medical prescriptions is well understood.

Several of the mineral and vegetable *Poisons* have been either first introduced into the materia

p The use of *Mercury* in the *Small-Pox* was resorted to, in the American Colonies, first in 1745, when it was employed with success, by Dr. THOMAS, a respectable practitioner of Virginia, and by Dr. MUIRISON, an eminent physician of Long-Island, in the province of New-York. See Dr. GALE's *Dissertation on Small-Pox*, quoted by Dr. HUXHAM.

medica, or used with unprecedented freedom in the course of the period under review. As a specimen of these it may be proper to mention *Arsenic*, *Conium Maculatum*, *Atropa Belladona*, *Solanum Dulcamara*, *Hyoscyamus*, and *Datura Stramonium*, which, with several others, have been often and usefully applied by modern physicians.

The introduction into medical use of the *Carolina Pink-Root (Spigelia Marylandica)*, by Dr. GARDEN, of South-Carolina; of the *Seneka Snake-Root (Polygala Seneka)*, by Dr. TENNANT, of Virginia; of *Gum Kino*, by Dr. FOTHERGILL; of *Cuprum Ammoniacum*, and of many new *Acids*, by various persons, may also be ranked among the less important of the class of improvements now under consideration.

Finally, it would be difficult to mention a single important article in the materia medica which, in the hands of the physicians of the eighteenth century, has not been better understood, better prepared, more extensively applied, or rendered more convenient and efficacious in its combinations, than in preceding times. Were it possible to include in this brief review a further detail of particulars, it would be easy to mention many great names, and various branches of science, to which the materia medica has been laid under great obligations in the course of this active and eventful period.

To the foregoing review it may not be improper to add, that the eighteenth century is distinguished above all preceding ages, by the number and excellence of *Medical Schools*. These have multiplied greatly, have been placed on a more extensive and liberal footing, and been more frequented than in any former period. At the be-

ginning of the century under review, and indeed during the former half of it, the University of Leyden was by far the most celebrated place of medical instruction. Next to this, in respectability, stood the schools of Italy. Soon afterwards the great school of Edinburgh began to be formed. In 1719, the first MONRO, of that city, undertook to deliver lectures on anatomy. He was in a short time joined by other able teachers, who formed a regular plan of medical instruction, and gained, in a few years, a high reputation. Indeed, for more than forty years the school at Edinburgh held the first rank, and was resorted to more than any other by students from all parts of the world. During the last twelve or fifteen years, that celebrated institution may, perhaps, be said to have, in some degree, declined; or rather to be more successfully rivalled than before, by several establishments for medical instruction, especially by some on the continent of Europe. The German medical schools, in particular, have lately much increased, both in number and excellence.

Medical Associations, for promoting the intercourse, combining the efforts, and diffusing the concentrated knowledge of many physicians, though not the exclusive product of the eighteenth century; yet, when considered with respect to their number and usefulness, may be ranked among the distinguishing honours of the period under consideration. They have been greatly multiplied during this period, in every civilized part of the world; have made many important publications, and eminently contributed to the advancement of the healing art. To recount the number of these established within the last hundred years, or to make the most general estimate of the services which they have rendered to the science of medicine, would fill many pages.

Next in importance to *Medical Schools* and *Societies*, are the *Medical Journals*, and other periodical publications, intended to promote the science of medicine, which distinguished the last age. It is believed that the honour of giving birth to this species of publication belongs to the century under review. At an early period of it, the *Transactions* of medical societies, and the collections of *Observations* and *Inquiries* on the various branches of the healing art, began to make their appearance, and to awaken the minds of practitioners. Among the regular *Journals* in the English language, exclusively devoted to this department of knowledge, the *Medical Commentaries* of Dr. DUNCAN, of Edinburgh, hold the first place, both with respect to time and merit. This work was succeeded by the *Annals of Medicine*, by the same gentleman, assisted by his son. Within the few last years of the century, works of this kind have greatly multiplied, not only in Great-Britain, but also in many other parts of the learned world. The great utility of these publications is unquestionable. The number of important hints which they have proposed, of new remedies which they have suggested, and of new paths of inquiry which they have opened, is too great to be reckoned. "It "is no exaggeration," says a learned American physician, "to assert, that the medical facts and "observations which have been published in the "eighteenth century, have done more towards ex-"plaining the functions, and curing the diseases "of the human body, than all that remained on "record, for many, perhaps for all the centuries "that had preceded since the creation."[q]

The establishment of numerous and extensive *Hospitals*, by which the eighteenth century is emi-

q RAMSAY's *Review of the Improvements of Medicine*, &c. p. 16, 17.

nently distinguished, may be considered as scarcely more favourable to the interests of humanity, than to the advancement of medical science. It has been well observed, that the *Heathen World never produced an Hospital;* and if any institutions of this kind now exist among pagans, they have derived from Christendom the benevolent plan. The astonishing multiplication of such establishments, in almost every part of the Christian world, and especially in Great-Britain, during the last century, is well known to every intelligent reader; and that every institution of this kind may be considered as a sort of medical school, from which the richest stores of instruction, both in surgery and the practice of physic, are continually drawn, is too obvious to require explanation.

To the peculiarities of the eighteenth century already stated, it may be added, that every branch of knowledge connected with the healing art has been rendered more *accessible* and *popular*, by the exertions of philanthropic and liberal minded physicians. For a number of preceding ages medical science was hidden under the veil of dead languages, and obscured by the technical jargon, and the love of mystery which long distinguished medical practitioners; but in the course of the century under consideration, and especially the latter half of it, the love of mystery, though not completely vanquished, has much declined. The elements of medical knowledge have been brought down to the capacities of all classes in the community. Plain and popular works for the use of *Families* have been presented to the public, and much useful knowledge respecting the best means, in ordinary cases, of preserving and restoring health, for the first time, generally disseminated. Among the many popular works of this kind, which might be mentioned, those of Tissot, Buchan, Willich,

and PARKINSON, have successively appeared, and acquired much distinction.

The different modes of making impressions on the human system, in various states of disease, through the medium of the imagination, and all the endless impositions of *Quackery* and *Charlatanism*, have been astonishingly multiplied in the course of the eighteenth century. Though medical knowledge has been evidently increasing, throughout this period, medical imposture has, at least, kept pace with it. Among many instances which might be adduced in support of this remark, may be mentioned the audacious pretensions of Count CAGLIOSTRO, with respect to his *Balsam of Life;* the far famed imposition concerning *Animal Magnetism*, by MESMER, and his followers; and more recently, the claims of *Perkinism*, so denominated from Dr. PERKINS, late a citizen of the United States. But it is worthy of remark, that while these kinds of imposture have rather gained ground, those which consist in *Witchcraft*, *Spells*, and *Incantations*, and all the supposed influence of *Demoniacal* powers, in producing health or disease, have manifestly declined within the period under review.

The cultivation and progress of medical science in the *United States* deserves some attention before closing this chapter. It is to be lamented that the want of suitable documents renders a full and satisfactory view of this part of the retrospect impossible. For though little was done in our country, for the science of medicine, until within the last forty years; yet of a considerable portion of that little the knowledge is either totally lost, or preserved only in that vague and indistinct manner in which traditional records are usually presented.

During the greater part of the century under review, and especially the early periods of it, medical science was cultivated with most success in the Middle and Southern States. This was, probably, among other circumstances, chiefly owing to the following causes. In those States many of the physicians were Europeans, who had enjoyed all the advantages of the best schools of physic. It was more common among them than in the Eastern States, owing to the greater wealth of the former, to send young gentlemen to complete their medical education in foreign universities. A taste for researches in natural history also appeared, in a number of instances, particularly in the States of *South-Carolina*, *Virginia*, *Pennsylvania*, and *New-York*, long before a similar taste was formed to the Eastward; and the tendency of such pursuits to enlighten the minds, and extend the inquiries of physicians, is too obvious to require elucidation.

One of the earliest publications in America[r] on a medical subject, was an essay on the *Iliac Passion*, by Dr. CADWALLADER, a respectable physician of Philadelphia, printed about the year 1740, in which the author opposes, with considerable talents and learning, the then common mode of treating that disease.[s] About the same time, Dr.

[r] Before this, WILLIAM BULL, the first native of South-Carolina, and probably among the first natives of America, who obtained a degree in medicine, defended and published, in 1734, at the University of Leyden, his inaugural thesis, *De Colica Pictonum*. He was a pupil of the great BOERHAAVE; and is quoted by Dr. VAN SWIETEN, in the following very respectful terms: *Hæc Colica in regionibus Americæ meridionalibus tam frequens est, ut fere pro morbo Endemio haberi possit; uti ab eruditissimo viro* GULIELMO BULL, *in his oris nato, et nunc feliciter ibi medicinam exercente, sæpius audivi, qui et pulchram de hoc morbo scripsit dissertationem inauguralem, quam in Academia Lugduno Batava defendit anno* 1734. Vide GERARDI L. B. VAN SWIETEN *Commentaria*, tomus tertius, p. 357.

[s] For several of the names and facts here stated, respecting the early medical writers of America, the author is indebted to the *Review of the Improvements of Medicine*, by Dr. RAMSAY, of Charleston, before quoted. The learning and talents displayed by this gentleman, both as an historian and medical philosopher, entitle him to a distinguished place among the benefactors and ornaments of his country.

TENNANT, of Virginia, published a small work on the *Pleurisy*, in which he brought into view the virtues of seneka snake-root, which were before unknown. Not long afterwards, Dr. JOHN MITCHEL, of Virginia, published an ingenious *Essay on the Causes of the different Colours of People in different Climates*, in which he displayed much anatomical and other learning.[t] About the middle of the century, Dr. THOMAS BOND, an eminent physician of Philadelphia, drew up some useful medical memoirs, which were published in a periodical work in London.[v] Nearly cotemporary with the last mentioned publications, were several by Dr. BENJAMIN GALE, a practitioner of medicine in Connecticut, who was much distinguished among his countrymen for his acquirements and skill, and who particularly published a *Dissertation on the Inoculation of the Small-Pox in America*, which has been often mentioned respectfully.[u] In 1753 Dr. JOHN LINING, of South-Carolina, published an accurate history of the American *Yellow Fever*, which was the first that was given to the world from our continent. Dr. LIONEL CHALMERS, of the same State, in 1754, communicated to the Medical Society of London some useful remarks on *Opisthotonus* and *Tetanus*, which were published in the first volume of their *Observations and Inquiries*. This gentleman also published, in 1767, an *Essay on Fevers*, in which he

t This Essay was sent to Mr. COLLINSON, of Great-Britain, and was intended as a solution of the prize problem on that subject, announced by the *Academy of Bourdeaux*. It was afterwards published in the *Philosophical Transactions*, vol. xliii. p. 102—150. Dr. MITCHEL also wrote ably on the *Yellow Fever*, as it appeared in Virginia in 1742. His instructive manuscripts on this subject fell into the hands of Dr. FRANKLIN, by whom they were communicated to Dr. RUSH. See RUSH on *Yellow Fever*, 8vo. 1794.

v *Medical Observations and Inquiries*, vols. i. and ii.

u It is possible that other medical publications were made in New-England, about this time, equally worthy of notice; but the author has not been so fortunate as to see or hear of them.

gave the outlines of the *spasmodic theory*, which had been before taught by HOFFMAN, and was afterwards more fully illustrated by CULLEN. In 1764 Dr. GARDEN, a scientific physician of South-Carolina, before mentioned, presented to the public an account of the medical properties of *Pink-Root*, and gave, at the same time, a botanical description of the plant. About the same time, Dr. COLDEN, and Dr. JACOB OGDEN, both of New-York, published some valuable observations on a species of *Sore Throat*, which was then prevalent and mortal. The former of these gentlemen also made medical communications on other subjects, which were esteemed.[w] To this list may be added Dr. JOHN JONES, also of New-York, who was greatly distinguished as a surgeon, and who published a work on *Wounds and Fractures*, which is an honourable monument of his learning and professional skill.

Though these physicians were not all of them natives of America; and though their publications were generally small, and cannot be said to be of much value at the present day; yet, considered as indications of a growing taste for medical inquiries, and as among the means of exciting, in a young country, a thirst for knowledge, and an ambition for the attainment of medical fame (as examples of which alone they are mentioned), they doubtless deserve respectful notice in this sketch. They contributed to bring the American practitioners of the healing art, scattered over an immense territory, better acquainted with each other, and, doubtless, concurred with other circumstances, to forward the plans of association and instruction which soon began to take place.

w Dr. COLDEN is the gentleman before mentioned as Lieutenant-Governor of New-York, and as having distinguished himself by his knowledge of *Astronomy* and *Botany*.

About the year 1762 Dr. WILLIAM SHIPPEN and Dr. JOHN MORGAN, both natives of Pennsylvania, and youthful friends, who had gone to the University of Edinburgh, to complete their medical education, and who had received its honours, met in London, whither they had repaired for the purpose of receiving instruction from the large hospitals, and excellent teachers of that city. They there agreed to attempt the establishment of a Medical School in Philadelphia. Accordingly, in the year 1764, Dr. SHIPPEN gave the first course of lectures upon *Anatomy* that ever was delivered in America. In 1765 Dr. MORGAN laid before the trustees of the College of Philadelphia a plan for teaching all the branches of medicine, and conferring medical degrees. This plan was adopted; Dr. SHIPPEN was recognized as Professor of *Anatomy*, and Dr. MORGAN was appointed Professor of the *Institutes of Medicine*, and soon afterwards began to teach them. In the year 1768 Dr. ADAM KUHN, who had studied under the celebrated LINNÆUS, was appointed Professor of *Botany*, and of the *Materia Medica;* and in 1769 Dr. BENJAMIN RUSH, who had just completed his medical studies in Europe, was chosen Professor of *Chemistry*. To these gentlemen was added Dr. THOMAS BOND, who was selected to give *Clinical Lectures*, on the cases of disease in the Pennsylvania Hospital. The first American Medical School, thus organized, became the resort of students from every part of the then Colonies: It has since undergone considerable changes, by the death and resignation of Professors, and new appointments; but continues to flourish; and will now bear a very honourable comparison, at least with regard to the talents and learning of its Professors, with the most respectable institutions of a similar kind in Europe.

In 1764 Dr. SHIPPEN lectured to *ten* students. In the season of 1801—2 the number of students attending the different Medical Professors amounted to *one hundred and thirty*, of whom *twenty-one* were admitted to the degree of Doctor of Medicine.

The laudable example set by the physicians and college of Philadelphia, soon excited the zeal of the physicians of New-York to establish a medical school in *King's College;* accordingly, in 1767 a letter was addressed to the governors of that institution, by Drs. SAMUEL CLOSSEY, PETER MIDDLETON, JOHN JONES, JAMES SMITH, SAMUEL BARD, and JOHN V. B. TENNENT, urging the propriety and importance of attempting to form a plan of medical instruction, and offering their services for carrying it into effect. In consequence of this letter the governors, a few days afterwards, elected Dr. CLOSSEY Professor of *Anatomy*, Dr. MIDDLETON Professor of *Physiology* and *Pathology*, Dr. JONES Professor of *Surgery*, Dr. SMITH Professor of *Chemistry* and *Materia Medica*, Dr. BARD Professor of the *Theory and Practice of Physic*, and Dr. TENNENT Professor of *Midwifery*. In 1770, in consequence of the death of Dr. TENNENT, and the removal of Dr. SMITH out of the province, the office of instruction in *Materia Medica* was committed to Dr. MIDDLETON, and *Chemistry* to Dr. BARD. Lectures were regularly given by the above named gentlemen; but no medical degrees had been conferred by the college, when the revolutionary war entirely deranged, and, in effect, destroyed the whole establishment.

In 1784 the Regents of the University made an attempt to revive the medical school, and went so far as to appoint several Professors in *Columbia College* (the new style by which *King's College* became known, on the change of government), for the pur-

pose of pursuing the former plan of instruction But the gentlemen so appointed did not all deliver lectures; the courses actually given were short and incomplete, and the undertaking languished, and finally fell to the ground.

After several other ineffectual attempts to establish a course of medical instruction in the city, the Trustees of Columbia College, in 1792, organized the school on its present plan, and commenced a course, which has succeeded better than any former attempt. The Faculty of Physic, as then constituted, consisted of Dr. SAMUEL BARD, *Dean;* Dr. WRIGHT POST,* Professor of *Anatomy;* Dr. WILLIAM HAMERSLEY, Professor of the *Institutes of Medicine;* Dr. JOHN R. B. RODGERS, Professor of *Midwifery;* Dr. NICHOLL, Professor of *Chemistry;* Dr. RICHARD KISSAM, Professor of *Botany;* and Dr. RICHARD BAYLEY, Professor of *Surgery.* These gentlemen, the greater number of whom had received a regular medical education in Europe, soon commenced the several departments of instruction assigned to them. The first medical degrees were conferred by this institution in 1793; and though it has not grown so rapidly as might have been expected, from the learning and talents of its Professors, yet it holds a respectable station, and has rendered very important services to the interest of medical science in the state.

The third medical school established in the United States, is that in the University of Cambridge, Massachusetts. This institution took its rise from the benefactions of several enlightened and liberal persons, who were desirous of pro-

* By means of the zeal and enterprise of Professor POST Columbia College is possessed of a valuable collection of *Anatomical Preparations;* to complete which that accomplished Anatomist made two voyages to Europe. It is believed that this is the first collection of the kind introduced into the United States, and certainly the best.

moting the knowledge of medical science. Dr. EZEKIEL HERSEY, an eminent physician of Hingham, in that State, who died in 1770, bequeathed one thousand pounds, Massachusetts currency, to be applied to the support of a Professor of *Anatomy and Surgery*. His widow, at her death, left a like sum, to be devoted to the same object. His brother, Dr. ABNER HERSEY, of Barnstable, and Dr. JOHN CUMMING, of Concord, left each five hundred pounds, to be also applied to the encouragement and support of medical instruction.[y] These generous donations were aided by that of WILLIAM ERVING, Esquire, an opulent gentleman of Boston, who, a few years afterwards, gave one thousand pounds towards the support of an additional Professor.[z]

Though the first of the benefactions above stated was made some time before the commencement of the revolutionary war, yet nothing effectual was done toward executing the will of these public spirited donors till near the close of it. In 1781 Dr. JOHN WARREN began to lecture in Boston on *Anatomy* and *Surgery*, and prosecuted his plan for two seasons. In 1783 the government of the University of Cambridge proceeded to organize a regular medical school, when Dr. WARREN was appointed Professor of *Anatomy* and *Surgery*; Dr. BENJAMIN WATERHOUSE, Professor of the *Theory and Practice of Physic*; and Dr. AARON DEXTER, Professor of *Chemistry* and *Materia Medica*. Since that period these gentlemen have regularly de-

y These several sums, amounting to three thousand pounds, Massachusetts currency, are funded, and their annual proceeds equally divided between the Professors of *Anatomy* and *Surgery*, and of the *Theory and Practice of Physic*; each of which Professorships bears the name of HERSEY.

z The bequest of Mr. ERVING was exclusively devoted by him to the support of a professorship of *Chemistry* and *Materia Medica*. This professorship also bears the name of its first and principal benefactor.

livered lectures on the several branches assigned to them; and though the number of students who usually attend them is comparatively small, yet they are annually increasing; and the erudition and talents of the Professors afford a satisfactory pledge that the institution will, at no distant period, reach a much higher station both of respectability and usefulness.

The fourth and last medical school formed in the United States, is that connected with *Dartmouth College*, in the State of New-Hampshire. This establishment, for instruction in medicine, was founded in the year 1798; when Dr. NATHAN SMITH was appointed Professor of *Medicine*, to lecture on *Anatomy*, *Surgery*, *Midwifery*, and the *Theory and Practice of Physic*; and Dr. LYMAN SPALDING Professor of *Chemistry* and *Materia Medica*. A considerable number of young gentlemen have attended the lectures, and several have received the honours of this institution.

The establishment of *Medical Schools* in the United States may be considered as forming a grand era in our national progress, and as producing important effects on the character of our physicians. The happy influence of these institutions has also been much aided by the formation of *Medical Societies*, in almost every State, which have all come into being within the last forty years. The effect of such establishments in exciting a thirst for the acquisition of knowledge; in producing a spirit of generous emulation; in cultivating a taste for observation and inquiry; and in combining the efforts and the skill of physicians, in every part of our country, must be obvious to every attentive mind. Many of the *Inaugural Theses*, defended and published by the students, in the American medical schools, would be considered as honoura-

ble specimens of talents and learning in the most renowned universities of Europe.[a]

Within the last fifteen years of the century under review, medical publications have greatly multiplied in the United States; many of which do equal honour to their authors and our country. Among these the numerous and valuable works of Dr. RUSH hold the first place; and to no individual are we more indebted for promoting, both by precept and example, that laudable and enlightened zeal for medical improvements, which has been so happily increasing, for a number of years past, among American physicians. In a catalogue of our medical writers also, Drs. MACLURG, MITCHILL, BARTON, RAMSAY, CALDWELL, CURRIE, and several others, would be entitled to particular notice, did not the limits of the present sketch forbid an attempt to do justice to their respective merits.

In the year 1797, a periodical publication, under the title of the *Medical Repository*, was commenced by Drs. MITCHILL, MILLER, and SMITH, which, from the peculiar circumstances of our country, may be considered as an important event, in noting the successive steps of medical improvement in the United States. In the premature death of the last named gentleman, who bid fair to attain the most honourable eminence in his profession, this work sustained a great loss.[b] It is still, how-

a Within the last ten or twelve years, all the medical schools in the United States have concurred in permitting their medical graduates to write and defend their *Inaugural Dissertations* in the English language. Whether this is to be considered as an improvement, or a literary retrocession, is a question which it is proposed to discuss in another place.

b Dr. ELIHU H. SMITH was born in the year 1771, at Litchfield, in the State of Connecticut, where his father, a respectable physician still resides. He entered Yale College at the age of eleven; and after leaving that institution, completed his education under the care of the Rev. Dr. DWIGHT, since President of Yale College, and who at that time presided over an academy of distinguished reputation at Greenfield. After this he pursued a regular course of medical studies under the direction of his father; commenced the practice of physic at Weathersfield in 1792, and removed

ever, prosecuted with undiminished excellence and success; and furnishes at once very reputable specimens of the learning, talents and zeal of many American physicians; and a most useful vehicle for conveying to the public a knowledge of every improvement in the science of medicine.

CHAPTER V.

GEOGRAPHY.

AS few sciences are more interesting than Geography, so few have received more attention, or been more improved and extended during the period under consideration. At the beginning of the century, almost half the surface of the globe was either entirely unknown, or the knowledge of it was so small and indistinct, as to be of little practical value. Since that time such discoveries and improvements have been made, that geography has assumed a new face, and become almost a new

to the city of New-York in 1793, where he remained until 1798, when he fell a victim to the yellow fever, which raged with so much violence in the city in the autumn of that year. The surviving Editors of the Medical Repository speak of their deceased colleague in the following honourable terms.

"As a physician, his loss is irreparable. He had explored, at his early age, an extent of medical learning, for which the longest lives are seldom found sufficient. His diligence and activity, his ardour and perseverance, knew no common bounds. The love of science and the impulse of philanthropy directed his whole professional career, and left little room for the calculations of emolument. He had formed vast designs of medical improvement, which embraced the whole family of mankind, were animated by the soul of benevolence, and aspired after every object of a liberal and dignified ambition. His writings, already published, incessantly awaken regret, that the number of them is not greater. They display singular diligence and acuteness of research, the talents of accurate and extensive observation, great force and precision of reasoning, and the range of a vigorous and comprehensive mind." *Medical Repository*, v. ii. p. 214, 215. *second Edition.*

science.[c] A spirit of curiosity has stimulated mankind to unprecedented activity in exploring remote regions of the earth. Individual voyagers and travellers, and private associations have done much to extend our acquaintance with the globe. Besides the exertions of these, the governments of Great-Britain, France, Spain, Sweden, Denmark and Russia have severally directed, or encouraged expeditions of discovery and of scientific research. To which we may add, that the occasional mistakes and misfortunes of mariners, while they overwhelmed with distress the immediate sufferers, have contributed to enlarge the sphere of our information with respect to distant countries, and thus, by a wise arrangement of Providence, to increase the objects and the means of naval enterprise.

Although in these geographical discoveries Great-Britain has undoubtedly made the most distinguished figure; yet, with respect to time, the honour of priority belongs to Russia. Early in the century, PETER the Great, to whose mind bold and grand enterprises were familiar and habitual, conceived the design of exploring regions of the earth, which had not been before visited by civilized man, and by this means promoting the wealth, cultivation, and aggrandizement of his empire. In pursuance of this design, he formed several expeditions for discovery, which, though not crowned with complete success, were yet considerably useful, and laid the foundation of greater attainments after his death. It was in his reign that several large districts of country in the north-eastern parts of Asia were first visited and explored by Euro-

c By *Geography* here is meant not only what the word strictly imports, viz. a description of the extent, divisions, and aspect of the surface of our globe, but also some of the other *statistical* inquiries, which modern writers, however improperly, have universally agreed to include in geographical treatises.

peans. Under his auspices, some enterprising navigators, in 1713, discovered the chain of islands called the *Kuriles*, on the coast of Kamtschatca. Under the direction of the same monarch, also, Captains Behring and Tschirikow discovered a number of other islands in the adjacent seas, and established a profitable trade with the natives. The former, a native of Denmark, in 1728, first entered the strait which divides Asia from the American continent, and which was afterwards called by his name.[d] This spirit of discovery continued to animate the government, but more particularly the subjects of Russia, for many years after the demise of the Czar. About this time some private adventurers in that country became fired with the ambition of discovering a north-east passage to India Between the years 1730 and 1740, many daring voyagers successively engaged in the prosecution of this plan. Among these, MoroviEF, Malgyn, Skurahoff, Menin, and Laptief, deserve particular notice.[e] The labours they underwent, and the dangers they encountered, were incredible; but all their exertions and discoveries served only to furnish increasing evidence, that if such a passage exist, it is next to impracticable, and always dangerous.

In 1740 Behring undertook another voyage, in the course of which, with wonderful fortitude and perseverance, he traversed the ocean, from

d Though Behring sailed into this strait, yet, probably owing to the fog, he did not discern land on the eastern side. The strait was more fully explored, a few years afterwards, by Capt. Cook, who gave it Behring's name. He discovered that the two continents, at this place, approach within forty miles of each other. It has been since ascertained, by the voyages of Meares, Dixon, Vancouver, La Perouse, and others, that to the north of this strait the Asiatic shore tends rapidly to the westward, while the American stretches nearly in a northern direction, till, at the distance of about four or five degrees, the continents are joined by solid and impenetrable bonds of ice.

e Mavor's *abridged Account of Russian Discoveries.*

the coast of Kamtschatka to the Isles of Japan, and furnished information which was highly useful to succeeding adventurers. He was followed by NEVODTSIKOFF, in 1745, PAIKOFF, in 1758, TOLSTYKE, in 1760, and various others of less note, by whom several additional groups of islands, in what is called the Northern Archipelago, were discovered, the character of their respective inhabitants ascertained, and new channels of trade laid open to the commercial world.

While the Russians were thus busily and successfully employed in exploring the north-eastern parts of Asia, and the seas between that country and the American coast, the Southern Ocean became an object of attention to several other European nations. In this immense field for the display of naval skill and enterprise, Captain WOODS ROGERS, an English commander, was the first who distinguished himself. He was followed by FEUILLIE, FREZIER, and BARBINAIS, all of France. To these succeeded CLIPPERTON and SHELVOCKE, of Great-Britian, who, in a voyage of some celebrity round the world, traversed the same seas. Though none of these navigators made very splendid discoveries, yet we are indebted to them all for many details of geographical information, which were at that time highly interesting, and served greatly to instruct and aid those who came after them.

In 1721 the Dutch West-India Company fitted out a squadron, under the command of Commodore ROGGEWEIN, and dispatched him to the Pacific Ocean, in search of unknown countries. The discovery of a Southern Continent was the particular object of this expedition. And although the respectable navigator to whom it was entrusted did not succeed in accomplishing his main purpose, yet he discovered a number of islands, and was

considered as having made a valuable addition to the geographical knowledge of his time.

In 1735 DON JUAN and DON ULLOA were sent, by command of the King of Spain, to South-America, on an expedition, which was before noticed, for ascertaining the *Figure of the Earth*. Few voyages have been more justly celebrated than this. By the labours of the bold and active Spaniards who conducted the undertaking, and by the faithful, accurate and enlightened observation of the French academicians who were united with them in the grand design, not only their primary object was gained, but large and valuable stores of information were furnished, in astronomy, geography, navigation, and the sciences in general.

Soon after the accession of GEORGE I. to the throne of Britain, he became fired with a zeal for discovery, which had for some time lain dormant in that country. Two voyages were accordingly set on foot, the one under the command of Captain MIDDLETON, and the other under the direction of Captains MOORE and SMYTH, with a view to discover a north-west passage, through Hudson's Bay, to the East-Indies. It is scarcely necessary to say that both these undertakings were unsuccessful with respect to their main object; still, however, they were productive of some useful information; as was also the celebrated voyage of Lord ANSON, undertaken principally for warlike purposes, about the same time.[f] When his present Britannic Majesty came to the crown, the same zeal for geographical discovery continued and increased. The delusive hope of finding a great Southern Continent, which had so long filled the minds of the learned, presented an in-

f The account of ANSON's Voyage, which is well drawn, was said to be executed by Dr. WALTERS, a gentleman who accompanied his lordship as chaplain; but the real compiler of the narrative was Mr. ROBINS.

viting object both to his love of science and his love of glory and aggrandizement. Accordingly Captains BYRON, WALLIS, and CARTERET, were successively dispatched, with orders to sail round the world, and to explore with particular care the Southern Ocean. The *Terra Australis incognita*, so fondly sought, continued to elude the search of these enterprising commanders; but they returned laden with much valuable knowledge of the numerous islands which they had discovered, and of other coasts and shores which they had viewed, and which were but partially known to preceding adventurers.

The idea of finding a north-east passage to India was, during a great part of the eighteenth century, generally entertained by navigators. It was before remarked, that the Russians, at an early period of the century, made numerous attempts to solve this important question in geography, but without success; excepting that each succeeding attempt rendered the practicability, and especially the safety of such a passage, still more improbable. In 1773 Captain PHIPPS, since Lord MULGRAVE, was dispatched, under the patronage of the British government, toward the North Pole, on a voyage of discovery. He proceeded as far as the 80th degree of north latitude, where the mountains of ice presented invincible opposition to his further progress. Although the expedition of PHIPPS confirmed the accounts given by the Russians, Dutch, and others, of the impracticability of a passage to the east, through those seas; and although it considerably increased our acquaintance with that part of the globe, not a few believe that such a passage really exists, and that it may yet be found.

But of all the circumnavigators and geographical discoverers who have distinguished the eighteenth

century, Captain JAMES COOK, of Great-Britain, ought undoubtedly to be viewed as the most illustrious, whether we consider the extent or the usefulness of his enterprises. His three voyages, undertaken by order, and at the expense of the British government, and performed between the years 1768 and 1779, were productive of a vast fund of knowledge, equally interesting and valuable, concerning the various parts of the world which he visited. He collected important original information, respecting islands and coasts long before discovered, and supposed to be well known. He discovered many others which had never been before visited by any European. And even where the honour of discovery could not be strictly ascribed to him, yet he observed with such accuracy, and described with such faithfulness, that the interests of science, of commerce, and of humanity, are perhaps more eminently indebted to him, than to any other individual in the same sphere of action, since the days of COLUMBUS.

The discoveries made by this celebrated circumnavigator were numerous. He ascertained that the idea, so long and fondly cherished by geographers, of the existence of a great southern continent, was either entirely without foundation; or, that if such a continent existed at all, it must be given up as inaccessible and useless to man. He demonstrated the impracticability of a north-west passage to India, which had been for so many generations an object of solicitude and pursuit, and which the attempts to discover had cost so many expensive voyages and lives. He fully ascertained the vicinity of Asia to the American continent, and thus determined the probability of the latter having been peopled from the former.[g] He discovered a

[g] Before the discovery of the vicinity of the Asiatic continent to America it had long been considered a question of difficult solution, how the

number of islands, particularly *New Caledonia*, and the *Sandwich Islands*, some of them large and populous, and presenting important objects of commercial and scientific pursuit. His observations threw much light on the manners, the trade, the affinities, and the probable origin of nations. And, finally, to the laudable exertions of this distinguished voyager, and to those of the learned men who accompanied him,[h] almost every branch of natural history is indebted for great and valuable improvements. And though to these important services his life was finally sacrificed; yet seldom has the memory of any man been loaded with more just and liberal honours, not only by his countrymen, but by the civilized world.

While Capt. COOK was accomplishing the splendid discoveries which have placed him above all rivalship in the history of modern navigation, the French government, desirous of signalizing itself in the same honourable career, began to project voyages for this purpose. Accordingly, in 1766 M. BOUGAINVILLE, a naval commander of talents and enterprise, was sent on a voyage of discovery, in the course of which he circumnavigated the globe. His discoveries were numerous and important, consisting, particularly, of a number of islands in the Pacific Ocean. He displayed great abilities as an officer, observed with accuracy, and reported with faithfulness; and the

latter became peopled, as the general *Deluge* destroyed all the inhabitants of the earth, excepting those who were miraculously preserved with NOAH, in the *Ark*, which is generally supposed, after the subsidence of the waters, to have rested on a mountain of Asia. So formidable did this difficulty appear to some, that it led them to renounce their belief in the sacred history. It is true, several plausible, and even probable suppositions might be made to avoid this impious alternative; but the discoveries of COOK, and succeeding navigators, show that there is no difficulty in the case. The two continents are now known to approach so near to each other, that, even throwing out of view the possibility of passing from one to the other on the *ice*, the passage might easily have been effected by means of *canoes*, or small *boats*.

h Sir JOSEPH BANKS, Dr. SOLANDER, Dr. FORSTER, and several others.

instruction with which his narrative abounds shows him to have been a man of an enlightened and liberal mind. In firmness, resolution, and talents for observation, he was probably little if at all inferior to the celebrated COOK; and although the list of his achievements is by no means so large, or so brilliant as those of the British commander, yet his voyage will long be accounted honourable to himself, to his sovereign, and to his country. To BOUGAINVILLE succeeded Messrs. PAGES and SURVILLE, who also made a number of valuable discoveries and observations, especially in the Southern Ocean, which have secured for their names an honourable place in the history of modern voyages. In 1771 KERGUELEN, MARION, and DU CLESMUR, were successively busied in exploring the same seas, in quest of a southern continent. And though the additions which they made to our knowledge of the globe were by no means great, yet they were such as to entitle them to respectful mention in the present sketch.

Soon after the peace of Paris, in 1783, a new voyage of discovery was projected by the French government, and preparation made for carrying it into effect. The objects of this expedition were to improve geography, astronomy, natural history, and philosophy in general; to collect accounts of the customs and manners of different nations; and to open new fields of commercial enterprise. Never, probably, was the plan of a voyage more enlightened and extensive, the instructions given to its conductors more scientific and precise, or the provision made for its execution more liberal and perfect.[i] The immediate direction of it was committed to Messrs. DE LA PEROUSE and DE LANGLE, accompanied by a number of learned men, who, in 1785, sailed

[i] See the voyage of LA PEROUSE, particularly vol. i.

from France, under the most favourable auspices. Seldom has any expedition of the kind excited so general an interest throughout the civilized world, or promised more brilliant success. The melancholy fate of LA PEROUSE and his companions is well known. Happily, however, all knowledge of the voyage is not lost with its unfortunate conductors. From the accounts which have been published, it appears that we are indebted to them for some important geographical discoveries, especially on the north-western coast of America, and on the eastern coast of Asia, and in the seas between that continent and Japan. From them, also, the accounts of some preceding navigators have received satisfactory confirmation; the mistakes of others have been corrected; and impositions under which the learned world had long lain, either through the ignorance or dishonesty of their authors, have been detected and removed.

The discovery of the great extent of *New-Holland* deserves to be mentioned among the most important acquisitions in modern geography.— That large portion of our globe, which may, indeed, be called, with propriety, a new *continent*;[j] had been discovered as early as the beginning of the seventeenth century, and, as some suppose, earlier;[k] but for more than a hundred years after this discovery, little was known respecting it. Many supposed it to be a part of the great southern continent, for which navigators had been so long and eagerly searching. In 1770 the celebrated Cap-

j The length of *New-Holland* is about 2730 miles, and its breadth about 1960; so that its extent is but a quarter less than that of *Europe*. It does not appear to be yet reduced to an absolute certainty, whether the whole of this great territory is a continued tract of land, or divided into two or more islands, by narrow straits.

k Mr PINKERTON, the latest, and probably the best systematic writer on Geography in the English language, seems rather inclined to adopt the opinion that New-Holland was discovered by the Portuguese and Spaniards, near a century before the Dutch navigators saw *Van Diemen's Land*.

tain COOK visited and explored the eastern coast of New-Holland, to the extent of near two thousand miles. In 1773 its *insular* situation was ascertained by Captain FURNEAUX. Since that period much geographical and other information respecting it has been obtained, and presented to the public, by HUNTER, MARSHALL, COLLINS, and several others, who have done much toward investigating the appearance and productions of some important portions of that extensive country.[l]

To the above may be added the discovery of the *Pelew Islands*, in 1783, by Captain WILSON; the discovery of several islands, a few years afterwards, by Captain SHORTLAND, between *New-Holland* and *Java;* the discovery of another cluster, about the same time, by Captain MARSHALL, in the seas between *New-Holland* and *China;* and the still more interesting information given us by the successive voyages of PORTLOCK, DIXON, ETCHES, MEARES, and VANCOUVER, concerning the north-western coast of America. By the last of these gentlemen, particularly, we have been made acquainted with the existence of islands, on that side of our continent, not less numerous or extensive than those on the eastern side; and with many new facts, which throw light on the geography, productions, and advantages of that part of the globe.

The Spanish nation was once among the most adventurous and enterprising in Europe. The discoveries made in former times under their auspices, and the talents and atchievements of their naval commanders, raised them high in the scale of national greatness. This spirit has been, in a great measure, dormant, for near a century and a half. Excepting the voyage of Don ULLOA,

l See the *Voyage of Governor* PHILLIP. 4to. 1789.

no expedition of any magnitude, for promoting knowledge, had been instituted by the Spanish government for a long time previous to that which is about to be mentioned. The published accounts of COOK'S voyages soon excited the curiosity and the jealousy of that nation. The government fitted out several vessels, at different times, for the purpose, and with the hope, of rivalling, if not surpassing, the exploits of the far-famed English discoverer. Of these attempts, the latest and most conspicuous was that made in 1789, under the direction of DON MALESPINA and DON BASTAMENTE. These commanders deserve an honourable place among the geographical discoverers of the century. They made many valuable maps and charts of coasts, particularly on the American continent, which, though visited before, had not been satisfactorily explored or delineated. They discovered a new cluster of islands in the Southern Ocean; and contributed not a little to extend our knowledge of navigation, natural history, and the habits and manners of various savage nations, of whom little was before known.

Besides the more distinguished voyages which have been enumerated, several others are entitled to notice in the present sketch, as having contributed to the improvement of geography. The voyages of NIEUHOFF and OSBECK, to *China,* early in the century; the voyage of CHABART, in 1753; that of COURTANVEAUX, in 1768; of STAVORINUS, to some of the Asiatic Islands, in 1768; of KERGUELEN, to *Iceland, Greenland, Shetland* and *Norway,* in 1772; of FORREST, in 1774; of DE LA CRENNIE, BORDA, and PINGRE, in 1778; of MARCHAND, round the world, in 1790; of ENTRECASTAUX, in search of LA PEROUSE; of the Missionaries to the South-Sea Islands, and several others, who have all furnished some new and valuable in-

formation concerning the countries which they respectively visited.

From the foregoing very imperfect view of what has been done by the principal *Naval* discoverers of the eighteenth century, to extend our knowledge of the globe, it will appear to form a great amount of geographical improvement. Their achievements, however, form but a part of our acquisitions in geography: for, while discoveries by sea have succeeded each other with astonishing rapidity, enterprising *Travellers* have been equally diligent, bold and persevering, in exploring the interior of countries before unknown, and in making us acquainted with their territorial limits, their governments, manners, riches, and science. Some notice of these will be necessary, in order to give a tolerable exhibition of modern advances in geographical knowledge.

At the beginning of the century under consideration, the greater part of *Asia* was comparatively little known. While the names of its various kingdoms, especially on the sea-coast, were familiar to the scholar, their internal limits and condition were very imperfectly understood even by the best informed. But, since that time, this defect of information has been so richly supplied, that little seems wanting to gratify the curiosity of the most inquisitive.

Peter the Great, after the battle of Pultowa, sent many Swedish prisoners into *Siberia*. Until that time little had been known concerning the interior of those northern regions. Strahlenberg, one of the prisoners, employed himself in exploring the country, for the promotion of geographical knowledge. He collected and published much important information; and his map of that

part of Asia which he delineated, and presented to the public in 1737, may be considered as laying the first foundation for any thing like accurate acquaintance with that portion of the Asiatic continent. The knowledge derived from STRAHLENBERG has been since greatly improved and extended by the travels of Professor PALLAS and others.

About the year 1716, Dr. SHAW, an English gentleman of character, travelled into *Syria* and *Palestine*, and collected much valuable information concerning those countries, particularly calculated to elucidate and confirm the sacred history. In 1720 Mr. BELL travelled, in the suite of the Russian Ambassador, from *Petersburgh* to *Pekin*, and, in the course of his journey, made many curious observations on that part of Asia through which he passed, which he afterwards presented to the public in a very interesting form. At several later periods *Syria* has been visited, and many additional accounts respecting it given by Mr. DAWKINS,[m] the Abbé MARITI, M. VOLNEY, M. CASSAS, and Mr. BROWNE. During the same period, our knowledge of *Arabia* has been extended by the travels of NIEBUHR, SAUVEBOEUF, and others. *Persia* has been also more fully explored than ever before, by HANWAY, Count DE FERRIERES, SAUVEBOEUF, FRANKLIN, GMELIN, PALLAS, and FORSTER. The geography and condition of *Hindostan* have been elucidated in a very interesting manner by HODGES, BARTHOLOMEO, FORSTER, and, above all, by Major RENNEL, whose map of that country, and his memoir accompanying it, have been pronounced, by a good judge, one of the most instructive and valuable geographical presents ever made to the public.[n]

m The materials collected by this gentleman, who visited Syria in 1751, were compiled into a very respectable and authentic work, entitled the *Ruins of Balbeck*, and published in 1757, by Mr. ROBERT WOOD.

n *Historical Disquisition concerning India.* By WILLIAM ROBERTSON, D.D. F.R.S. 8vo. 1791. *Preface.*

Toward the close of the seventeenth century, some valuable information respecting *China* had been obtained through the medium of Christian Missionaries from Europe. Since that period our acquaintance with China has been greatly extended. For this we are chiefly indebted to the works of DU HALDE, GROSSIER, STAUNTON, and VAN BRAAM. Few works have been read with more interest than the celebrated account of Lord MACARTNEY'S Embassy, by Sir GEORGE STAUNTON; and seldom has any work of the kind been found more rich in curious information.—*Tartary* has been, during the same time, partially explored by various travellers; the *Birman Empire*, by SYMMES; *Tibet*, by TURNER; *Kamtschatka*, by BELL, LESSEPS, and others.—To the above sources of information concerning different parts of Asia, may be added the *Asiatic Society* at *Calcutta*, and particularly its late illustrious President, Sir WILLIAM JONES, whose diligence and success in investigating every avenue of knowledge, relating to the arts, sciences, literature, government, morals and religion of the principal Eastern Empires, were only equalled by his exalted virtues, and his stupendous general learning, which render him a prodigy of the age in which he lived.[o]

Much new and valuable information respecting the *Asiatic Isles* has also been obtained, and laid before the public, by various modern travellers. Since the time of KŒMPFER, *Japan* has been visited by THUNBERG, and others, who have made interesting additions to what was before known concerning that empire. The *Philippine Islands* have been successively visited and examined by SONNERAT, FORREST, and STAVORINUS; the *Sunda*

[o] See his *Works*, lately published, with great splendor, in 6 vols. 4to. See also the *Asiatic Researches*—*passim.*

Islands, by BEECKMAN, MARSDEN, FOERSCH,[p] SONNERAT, THUNBERG, FORREST, and LE POIVRE; *Amboyna* and *Celebes* by RUMPHIUS; and *Ceylon* by THUNBERG; besides the numberless details received concerning less important islands, and by less conspicuous travellers, at different periods of the century.

At the commencement of the period under review, the interior of *Africa* was even less known than the Asiatic continent. In fact, little more had been done than to survey the coasts, and to mark the capes and harbours of this quarter of the globe. But since that time, by the exertions of a number of intelligent and persevering travellers, our knowledge of that extensive country has rapidly increased; and there seems to be a fair prospect of our curiosity being, at no great distance of time, much more fully gratified. Early in the century, the travels of Dr. SHAW into *Barbary*, of POCOCKE and NORDEN into *Egypt*, and of KOLBEN to the

p FOERSCH's narrations are not always to be relied on. His celebrated account of the *Bohun Upas* tree, said to grow in the Island of *Java*, has been long a monument of his credulity, or of his disposition to exaggerate. It is somewhat surprising that Dr. DARWIN should treat this account with so much respect. (See the notes to his *Botanic Garden.*) The truth is, if we may credit the declaration of the most creditable modern travellers, no such tree exists. It is certain, however, that the vegetable poisons of some Asiatic islands are uncommonly numerous and extremely virulent. In the island of *Celebes* they are so frequent and deadly that it has been called the *Isle of Poisons*. It produces, we are told, the dreadful *Macassar* poison, a gum which exudes from the leaves and bark of a species of *rhus*, probably the *toxicodendron*. This species, together with the other poisonous trees on the same island, is called by the natives *ipo* or *upas*. Such, indeed, is the deleterious activity of this tree, that, when deprived of all poetic exaggeration, it still remains unrivalled in its powers of destruction. From the sober narrative of RUMPHIUS, we learn that no other vegetable can live within a nearer distance than a stone's throw; that birds, accidentally lighting on its branches, are immediately killed by the poisonous atmosphere which surrounds it; and that, in order to procure the juice with safety, it is necessary to cover the whole body with a thick cotton cloth. If a person approach it bare-headed, it causes the hair to fall off; and a drop of the fresh juice, applied on the skin, if it do not produce immediate death, will cause an ulcer very difficult to be cured.—See PINKERTON's *Geography*, vol. i. p. 517.

Cape of Good-Hope and the parts adjacent, furnished the civilized world with much valuable information concerning those countries. At later periods *Egypt* has been explored upon a more satisfactory and philosophical plan, by NIEBUHR, a commissioner of the King of Denmark for this purpose; and by SAVARY, VOLNEY, and SONNINI, distinguished travellers of France. To which may be added the interesting communications respecting the geography and natural history of that country, by the learned men lately sent thither, in connection with the far-famed and extraordinary expedition by the French government.

The interior of *Southern Africa* has, within a few years past, been explored and made known to us by DE LA CAILLE, THUNBERG, SPARMAN, VAILLANT,[q] PATTERSON, and BARROW; while the *Northern* parts have been visited and examined by POIRET, LEMPRIERE, CHENIER, HOEST, AGRELL, and others; from whose travels a great mass of new and curious facts may be derived, respecting the natural, civil, and moral condition of those barbarous countries.

Prior to the year 1768 little had been heard or known of the great kingdom of *Abyssinia*, from the time of the Jesuit LOBO, until that period. It was in the above mentioned year that Mr. BRUCE, a Scottish gentleman, well known in the annals of modern travel, undertook to explore that extensive territory, with a particular view to ascertain the source of the *Nile*. The dangers which he encountered in this enterprise, the difficulties which he overcame, and the views which he exhibits of the countries which he visited, present a very

q Both SPARMAN and VAILLANT, especially the latter, have been charged with being deficient in that first of all requisites in a traveller, *fidelity*. But allowing for a mixture of fiction in their statements, they have certainly given us much curious and valuable information.

amusing and instructive spectacle to the inquiring mind, notwithstanding the occasional errors into which he falls, and the inordinate vanity which appears in every page of his narration. It has been said, that to this ardent and intrepid man we are indebted for more important and more accurate information concerning the interior of Africa, and especially concerning the nations established near the Nile, from its source to its mouths, than all Europe could before have supplied. After BRUCE, the next traveller of note, who undertook to explore the same country, and the parts adjacent, was Mr. BROWNE, who went through *Abyssinia* and *Egypt*; visited several large districts into which Europeans had never before penetrated; and, by the account given to the public of his travels, has considerably enlarged the sum of our geographical knowledge.

In 1788 a number of the nobility, and other gentlemen of liberal curiosity, in Great-Britain, formed an association, the express object of which was to explore the interior of Africa. This object they have pursued with a laudable zeal, and with a very honourable and gratifying success.[r] The successive travels of HOUGHTON, LUCAS, LEDYARD,[s] and PARK, under their direction, have

r See the *Proceedings of the African Association.*

s Mr. JOHN LEDYARD was an American, born in the State of Connecticut. He entered Dartmouth College, in New-Hampshire, at the usual age, with a view to the study of Divinity; but, being obliged to leave that institution, on account of the narrowness of his circumstances, before his education was completed, he resolved to indulge his taste for activity and enterprise. Accordingly, he engaged as a common sailor on board a ship bound from New-York to London. On his arrival there he entered as corporal of marines with the celebrated Capt. COOK, then about to sail on his third voyage of discovery. Young LEDYARD was a favourite with that illustrious navigator, and was one of the witnesses of his tragical end. After this he travelled many thousand miles through the northern parts of Europe and Asia, intending to pass from the latter to the American continent, and traverse the interior of his native country. But being arrested in the pursuit of this plan by order of the Empress of Russia, he at length returned to England, where, in 1788, he engaged in the service of the African Asso-

been productive of much new and curious information concerning the countries which they visited. The last of these gentlemen, in particular, has recently brought to our knowledge a more interesting and important number of facts concerning the moral, political, and physical condition of *Western Africa*, than had been done by any preceding traveller.[t] Nor is it a circumstance of small moment, in estimating the value of Mr. PARK's travels, that they have called forth, from Major RENNELL, a most learned and instructive body of remarks, and other materials for throwing light on the geography of that extensive country. The succession of maps, delineating important portions of Africa, published by this last named gentleman, between 1790 and 1800, forms a curious series of documents respecting our progressive knowledge of that quarter of the globe. The publications of LOYART and DEGRANDPRE also contain some valuable information concerning *Western Africa*, particularly the large territory included under the names of *Congo* and *Loango*.

In 1791 a society was formed in Great-Britain, by a number of benevolent persons, under the name of the *Sierra Leona Company*. The principal design of this society was to obtain a settlement, on that part of the coast of Africa called by the name, which they assumed, for a large body of destitute Africans, or descendants of Africans, then in the British dominions; and, through the medium of this colonial establishment, to do something toward the introduction of knowledge and civiliza-

ciation, for the purpose of exploring the interior of that country. In pursuance of this agreement, he reached Cairo, in Egypt, in the month of August of the same year. He had, however, proceeded but little way on his travels, when death unexpectedly terminated his career.

t The narrative of PARK's journey is said to have been written by the late BRYAN EDWARDS. See *History of the West-Indies*, vol. iii. Advertisement by Sir WILLIAM YOUNG.

tion into those benighted regions. Although instituted with a different view, the exertions of this society have subserved the cause of geographical discovery. The messengers and agents of the association have added not a little to our knowledge of Africa. Among these, Messrs. WATT and WINTERBOTHAM deserve to be honourably mentioned. Their enterprising journey into the interior of the country, and especially the information which they furnished respecting the *Foulah* nation, entitles them to the thanks of every lover of humanity and of science.

New light, of a curious and interesting kind, has also been thrown, during the period under review, on the geography and condition of some of the *African Islands*. For much of this information we are indebted to FLACOURT, ADANSON, ROCHON, MARION, COOK, GRANT, and BERNARDIN DE ST. PIERRE. Several of these gentlemen observed with a philosophic eye, and communicated their knowledge with a scientific precision, which it may be asserted are found with peculiar frequency among modern travellers.

A large portion of *Europe* was so well known, antecedently to the commencement of the period which we are considering, that geographical *discoveries* could scarcely have any place with respect to it. But from this general remark must be excepted the Empire of *Russia*, and *Turkey in Europe*. Concerning these important portions of the globe, the last age has brought to light much valuable information beyond what the most learned of the preceding century possessed.

When PETER the Great mounted the throne, the *Russian Empire* was, properly speaking, ranked among the *incognita* of the earth. That celebrated monarch early engaged in projects for exploring the interior of his vast dominions, and developing

the resources, the capacities, and the wants of his people. Much was done, during his reign, toward the accomplishment of this object; but he left still more to be performed by his successors. His design was prosecuted with great zeal and success, by CATHARINE II. who, in 1768, sent a number of learned men to different parts of her extensive empire, to ascertain its physical, moral, and political condition. They were ordered to pursue their inquiry upon the different sorts of earths and waters; upon the best methods of cultivating the barren and desert spots; upon the local disorders incident to man and animals, and the most efficacious means of relieving them; upon the breeding of cattle, and particularly of sheep; on the rearing of bees and silk worms; on the different places and objects of fishing and hunting; on minerals; on arts and trades; and on forming a *Flora Russica*, or collection of indigenous plants. They were particularly instructed to rectify the longitude and latitude of the principal towns; to make astronomical, geographical, and meteorological observations; to trace the courses of the rivers; to make exact maps and charts; to be very distinct and accurate in remarking and describing the manners and customs of the different people, their dress, languages, antiquities, traditions, history, and religion; and, in a word, to gain every information which might tend to illustrate the real state of the whole empire.[v]

In this arduous service, PALLAS, GMELIN, LEPECHEN, GULDENSTÆDT, and others, were, about the same time, employed, and furnished with every accommodation, in the power of their royal patron, which could facilitate their pursuit. It is generally known that they performed the task committed to

v COXE's *Travels into Russia*, &c. vol. ii. p. 350, 351, &c. For the particular account of the different routes, &c. of these learned travellers, see TOOKE's *View of Russia, Introductory Discourse.*

them with ability and faithfulness; and that they collected and communicated rich stores of knowledge relating to the districts which they respectively visited. Indeed, their researches may be considered as the basis of all the best and most authentic accounts which have been subsequently given to the world concerning that growing empire. The observations made by Professor PALLAS, during his laborious and persevering tours, have been regarded as peculiarly instructive and valuable.

Since the travels and discoveries of the Petersburgh academicians above named, a number of other travellers have adventured in the same ample field of observation and inquiry. There is not room in this place to recount their names or achievements. The travels of Mr. COXE, the well known British tourist, in that country, furnish the reader with much instruction and entertainment. But probably the most complete and satisfactory accounts of Russia now extant, are to be found in the *Physical, Moral, Civil, and Political History of Russia, ancient and modern*, by M. LE CLERC; in the *Description of all the Nations in the Russian Empire*, by M. GEORGE; and, lastly, in the *View of the Russian Empire*, by Mr. TOOKE.

Concerning *Turkey in Europe*, the progress of our knowledge has been slower and less interesting. It still remains, in a great measure, among the unknown parts of the earth. But there is little ground to regret our ignorance of it, since there seems abundant reason to conclude, that it presents but few grand or pleasing objects to the inquiring mind. Fixed as it were, in a state of intellectual and moral congelation, its inhabitants offer nothing to interest, or to instruct, save an example of evils to be abhorred and avoided. Such, however, as they and their country are, we have derived some

valuable information concerning them from various sources. Among these, perhaps, the most respectable are the accounts of PEYSSONELLE, SESTINI, GUYS, and TODERINI; the travels of Baron DE TOTT, DEMO, STEPHENOPOLI, BOSCOVICH, and SCROFANI; to which may be added, as in a certain view worthy of attention, those of Lady MONTAGUE, Lady CRAVEN, and Mr. DALLAWAY. But probably the most full and satisfactory account of this portion of the globe, to be found in any one work, is comprised in the *Survey of Turkey*, by Mr. ETON. From these sources a tolerable idea may be formed, not only of the geography, strictly speaking, but also of the manners, arts, literature, and general condition of that degraded country.

Besides the travellers above mentioned, who have explored the interior of countries before little known, the last century is remarkable for having produced an unprecedented number of that species of works denominated *Travels*, *Tours*, and *Journies* into parts of the world before generally known, and frequently visited. To attempt an enumeration of these would far exceed the limits of the present sketch; and to select a small portion out of the immense number, would almost necessarily involve some injustice to the rest. Though these travellers have added little to the stock of geographical knowledge, properly so called, they have thrown much light on the manners and customs of various nations; they have made the literati of different countries better acquainted with each other, and many of them abound with pictures of human nature at once lively, just, new, and highly interesting. Perhaps, indeed, this characteristic of modern travels deserves to be mentioned as, in some degree, peculiar to the last age. That there is a philosophic cast, an attention to the different shades of human character, and an aspect of

scientific inquiry more prevalent in some late productions of this class, than can be found in most of their predecessors, has probably been often remarked by the most superficial readers.

At the beginning of the eighteenth century, by far the greater part of the *American Continent*, and even of what is now called the *United States*, was unknown territory. Since that time a considerable portion of it has been explored, and much curious information respecting it furnished by numerous travellers.

Different portions of the southern and south-western parts of *North-America* have been visited and explored, during the period under review, by LAWSON,[u] BOSSU,[w] BRICKELL, ADAIR,[x] BARTRAM,[y] D'AUTEROCHE, and CLAVIGERO,[z] whose publications abound with instructive and interesting narratives concerning the territorial limits, the inhabitants, and the natural history of the districts which they traversed. Much information concerning the geography of the western parts of North-America has been given by BOON, CARVER,[a] HUTCHINS, and others; and the northern and north-western, by CHARLEVOIX, CURRY, LONG,[b] POND, CARTWRIGHT, HEARNE,[c] HENRY, TURNER, and MACKENZIE. The last named traveller has the honour of being the first white man who ever reached the Pacific Ocean by an over-land progress from the east.[d]

u *A New Voyage to Carolina, containing the exact description, and Natural History of that country.* 4to. 1709.

w *Travels in Louisiana.* Translated by FORSTER. 2 vols. 8vo. 1771.

x *Account of the American Indians.*

y *Travels through North and South-Carolina, Georgia, &c.*

z *History of Mexico.* 2 vols. 4to.

a *Travels.*

b *Travels of an Indian Interpreter.* 4to.

c *Journey from Prince of Wales's Fort, in Hudson's Bay, to the Northern Ocean.* 4to. 1795.

d Mr. MACKENZIE, now Sir ALEXANDER MACKENZIE, ascertained, beyond all dispute, that there is no northern communication between the

Besides the travellers who, with laudable enterprise, have done much toward exploring such parts of our country as were, a few years ago, wholly unknown, we are indebted to many other gentlemen for various publications, which have served greatly to improve American geography. The *Geographical Essays* of LEWIS EVANS, published in 1755, together with the maps accompanying them, formed an important step in the progress of our knowledge of that part of America of which he treated. The geography of *Virginia* has been well illustrated by Mr. JEFFERSON; of *Kentucky*, by Mr. IMLAY; of *New-Hampshire*, by Dr. BELKNAP; of *Vermont*, by Dr. WILLIAMS; and of the District of *Maine*, by Mr. SULLIVAN. But the most full and satisfactory work on American geography, hitherto given to the public, is that by the Rev. Dr. MORSE, whose talents, zeal, and industry, in collecting and digesting a large amount of information on this subject, are well known, both in Europe and America, and have been very honourably rewarded by public patronage.

The geography of *South-America*, though far from being so fully and accurately understood as could be wished, has yet been much investigated and made known during the last age. At an early period of the century Don ULLOA, who was before mentioned, visited and spent much time in *Peru*, *Chili*, the kingdom of *New-Granada*, and several of the provinces bordering on the *Mexican Gulph*. At the same period, and in the same part of the New World, Messrs. CONDAMINE, GODIN, and BOUGUER, travelled for several years, and communicated to the public a great variety, and a very valuable amount of information respecting

Atlantic and Pacific Oceans, except at so high a latitude as to be rendered wholly impracticable by perpetual ice. This long contested question will probably be considered henceforth as settled.

the interior of those extensive countries. The travels also of CATTANEO, HELMS, and DOBRIZHOFFER, in *Peru* and *Paraguay;* of BANCROFT and STEDMAN, in *Guiana;* of ARMATEUR, in *Cayenne;* and of FALKNER, in *Patagonia,* have contributed greatly to enlarge the sphere of our knowledge respecting the southern division of this western continent. Don MALESPIÑA, before mentioned, made an excellent survey of the coast, from *Rio de Plata* to *Panama.* But the best geographical view ever published of a large portion of South-America is exhibited in the *Mapa Geographica del America Meridional,* published in 1775, by Don JUAN DE LA CRUZ, Geographer to the King of Spain.[e]

Besides all the discoveries and improvements stated in the foregoing pages, and to which the enterprise of navigators and travellers has given birth, the last age is distinguished, above all others, by the production of large and excellent systematic works on the subject of geography. The difference in fulness and accuracy, between the geographical treatises published at the commencement of the eighteenth century, and those which appeared toward the close of it, can be adequately conceived by none but those who have compared them together. The successive works of GORDON, BOWEN, MIDDLETON, COLLYER, SALMON, GUTHRIE,[f] and PAYNE, held an important rank at the dates of their respective publications. The extensive geographical work of Mr. BUSCH-

e This map was republished, in London, with improvements, by FADEN, in 1799.

f This work, it is said, was not compiled by GUTHRIE, whose name it bears, but by another person, who had the permission to avail himself of the popularity of that gentleman's character. The stratagem succeeded; the work, with all its deficiences and errors, immediately gained general patronage, and entirely supplanted SALMON's Geographical Grammar, which had before enjoyed universal favour.

ING, of Germany, may be considered as, on the whole, the most laborious and complete of the age. To these may be added the large and very respectable work of Professor EBELING on the geography of America,[g] and that of BRUNS on Africa.

The elucidations of *Ancient Geography*, by several modern writers, are highly interesting and valuable, and deserve to be regarded among the signal improvements of the eighteenth century. The service rendered to science in this way by M. D'ANVILLE, is too well known to require eulogium. The more recent works, of a similar kind, by GOSSELLIN, of France, and by RENNELL, of Great-Britain, also do honour to their authors, and to the age.

In few respects has the last century displayed greater improvement than in the number, accuracy, and elegance of its *Maps*. The maps of M. DELISLE were early and extensively celebrated. Since that time the maps of CASSINI,[h] D'ANVILLE, LA ROCHETTE, ROBERT, WELLS, SOTTZMAN, RENNELL, ARROWSMITH, and many others, are entitled to honourable distinction. At the beginning of the period under review there was scarcely a map in existence of any part of the American continent, that deserved the name. Since that time almost every known part, and especially the United States, have been delineated with accuracy and neatness.[i] The

g The diligence and success with which Professor EBELING has laboured to elucidate the Geography and History of the American States, are worthy of the highest praise. There is no doubt that the information which he has collected, and has been for some time engaged in laying before his countrymen, on this subject, though in some respects imperfect and erroneous, as was unavoidable, is yet by far the most accurate and full that was ever given to the public by an European.

h The map of France, by CASSINI, was begun in 1744, and finished in 1794, in one hundred and eighty three sheets. This is probably the largest map ever formed by human industry.

i It was the wish of the author to have given a list of the best maps of the several American States, which have been formed in the course of the

Charts which have been formed in modern times are also distinguished by their excellence, above all preceding specimens. Among these the *Neptune Orientale* of M. De Mannivilette, the charts of the Atlantic, by Bellin; of the Pacific, by Arrowsmith; of the American coast, by Du Barres and Malespina; of the Western Isles, by Huddart; of the coasts of Spain, by Tofino; the numerous charts of detached islands, coasts, harbours, and straits, by Dalrymple, are among the most respectable. Besides these the charts by Mount, Davidson, Murdock, Laurie, Gilbert, Whittle, Heather, and many more, deserve honourable notice.

The *Gazetteers*, *Atlasses*, and other helps to the acquisition of geographical knowledge, have also become very numerous during the last age. They were not only less common in former periods, but, in fact, little known, and of small comparative value. Their introduction into popular use is a peculiarity of the eighteenth century. The authors and compilers of these are so generally known, that it is unnecessary to enumerate them. Those of Crutwell, Scott, and the Rev. Dr. Morse, are among the latest and best in our language.

Unprecedented pains have been taken, during the period under consideration, to collect into regular series of volumes those accounts of *voyages* and *travels* which might serve to give a connected view of the condition of the globe, and of the activity and adventures of distinguished men

period under review; but the want of correct information deterred him from the attempt. A good map of the State of New-York has been long a *desideratum*. This deficiency is likely to be soon supplied by Simeon De Witt, Esq. Surveyor-General of New-York, who has a large and splendid map of the State in considerable forwardness. From the well known skill and accuracy of this gentleman, little doubt can be entertained but that his work will meet the wishes, and abundantly deserve the patronage of the public.

in exploring distant countries. The collections of this nature formed by HARRIS, CAMPBELL, CHURCHILL, SALMON, GUTHRIE, HAWKSWORTH, DALRYMPLE, and MAVOR, of Great-Britain; by DES BROSSES, of France; by ESTALA, of Spain; and many others, hold an important rank among the instructive and amusing productions of the age.

The discoveries and improvements above stated, besides correcting and enlarging our geographical knowledge, have also led to many and important additions to the stock of *general science.* There is scarcely any part of natural philosophy, or natural history, which has not received considerable improvement from this source. New light has been thereby shed on the doctrines of the *tides,* and the *winds;* the nature and laws of *magnetic variations* have been better understood; the sciences of *zoology, botany,* and *mineralogy* have been greatly extended and advanced; immense collections of natural *curiosities* have been made from every known region of the earth; and, what is by no means of least importance, opportunities have been afforded of studying *human nature* in a great variety of forms, of making rich collections from the vocabularies of different *languages*, of comparing *habits* and *customs*, of investigating the *records* and *traditions* of nations scarcely at all known before; and thus of acquiring rich materials towards completing the natural and civil history of man.

Strange as it may appear, our knowledge of *Antiquities*, principally by means of geographical discoveries, and the inquiries naturally flowing from them, has become incomparably greater than was ever before possessed by man. "When the "*Egyptians*," says a modern eloquent writer, "called the *Greeks children in Antiquities*, we may

"well call them children; and so we may call all "those nations which were able to trace the pro- "gress of society only within their own limits. "But now the great map of mankind is unrolled "at once, and there is no state or gradation of "barbarism, and no mode of refinement, which "we have not at the same moment under our "view: the very different civility of Europe and "of China; the barbarism of Persia and Abyssinia; "the erratic manners of Tartary and of Arabia; "the savage state of North-America, and of New- "Zealand, are all spread before us; we have em- "ployed philosophy to judge on manners, and "from manners we have drawn new resources for "philosophy."[j]

Geographical discoveries have led to an unprecedented degree of *intercourse among men.* Though this remark is connected with the subject of the last paragraph, it deserves separate consideration. Toward the close of the seventeenth century, the intercourse between distant nations of the earth was greater than it had been at any former period, and was considered highly honourable to human enterprise: but since that period it has been increased to a wonderful degree; insomuch that at the present time, the inhabitants of the remotest countries have seen and know more of each other, than those, in many cases, who resided comparatively in the same neighbourhood an hundred years ago.

Great advantages to *Commerce* have also arisen from the geographical discoveries above recited. The extension of the *fur-trade* to the north-west coast of America, is one important and beneficial event of this nature. This article of commerce was rapidly becoming more scarce in those parts

[j] See BURKE's *Letter* to ROBERTSON, in Professor STEWART's *Account of the Life and Writings* of that historian.

of the world from which traders had before obtained it: it was, therefore, a most seasonable and interesting discovery to make them acquainted with a coast on which they might be supplied with the greatest abundance, and which is likely to furnish an inexhaustible store for ages to come. To this signal commercial advantage might be added many others, were it expedient to enlarge on the subject. It would be improper, however, to omit taking notice, that the numerous groups of Islands, lately discovered in the Pacific Ocean, have risen to unexpected importance, and promise to be of still greater utility. These Islands afford very convenient victualling and watering places for ships; and if the civilized nations who visit them were as industrious and successful in introducing among them the blessings of literary, moral and religious knowledge, and the arts of cultivated life, as in initiating them into the vices which corrupt and degrade, we might expect soon to see them become the happy seats of literature, science, arts, and pure Christianity, and, in time, reflecting rich blessings on their benefactors.

The enlargement of geographical knowledge during the late century, has led to an *increase of the comforts and elegancies of life*, in almost every part of the civilized world. By this means the productions of every climate have become known and enjoyed in every other; the inventions and improvements of one country have been communicated to the most distant regions; and the comforts of living, and the refinement of luxury, have gained a degree of prevalence among mankind greatly beyond all former precedent. Never, assuredly, in any former age, were so many of the natural productions, and the manufactures of different countries enjoyed by so large a portion of the human race as at the close of the eighteenth century.

Finally, the geographical discoveries of the last age have contributed to *illustrate and confirm Revelation*. The discoveries of BEHRING and COOK were before-mentioned as throwing light on the population of the New World, and thus tending to support the sacred history. But, besides these, the knowledge gained by modern voyagers and travellers, of the manners, customs, and traditions of different nations, especially of those on the Eastern Continent, has served to illustrate the meaning, and unfold the beauty of many passages of scripture, before obscure, if not unintelligible; and has furnished abundant and striking evidence in support of the Mosaic account of the common origin, the character, the dispersion, and the subsequent history of mankind.[k]

CHAPTER VI.

MATHEMATICS.

THE seventeenth century was the "golden age" of mathematical science. Never, since the revival of learning, has this branch of knowledge been cultivated with such brilliant success as during that period. The grand inventions of *Logarithms*, by NAPIER, and of *Fluxions*, by NEWTON, together with the numerous discoveries and improvements of DES CARTES, BRIGGS, KEPLER, GREGORY, LEIBNITZ, and many others, must ever render the age of those great men a distinguished æra in the annals of mathematics. It is even possible that the grand discoveries of these philosophers, and the

[k] It is intended to illustrate this point more fully in a subsequent part of this work.

unusual lustre of their characters, may have contributed, by an influence far from being unnatural, to repress the ambition and discourage the exertions of some who came after them. But, although the eighteenth century can boast of no discoveries so splendid, nor of any advances so honourable, as belong to the preceding, yet it produced both, in a sufficient degree to secure a reputable place in the history of this sublime science.

Though the *Fluxionary Analysis* had been invented by NEWTON thirty years before, yet that great mathematician first published his new doctrine on this subject in 1704. The controversy in which he became involved with LEIBNITZ, in consequence of this publication, is well known to have been one of the most curious and interesting of the age.[l] It seems to have been long and generally agreed, that the credit of this celebrated invention is due to the illustrious British philosopher, and, of course, that the claim of his German rival was unfounded.[m]

l Soon after NEWTON published his doctrine of *Fluxions*, his book was reviewed in the *Acta Eruditorum* of Leipsic. In the course of this review, an intimation was given that he had borrowed from LEIBNITZ, and that the honour of the invention properly belonged to the latter. Dr. KEILL, Professor of Astronomy in the University of Oxford, undertook the defence of his countryman. After a number of controversial papers had been exchanged on the subject, LEIBNITZ complained to the Royal Society of injustice on the part of NEWTON and his friends. The Society appointed a committee of its members to investigate the questions in dispute, who, after examining all the letters and other papers relating to it, decided in favour of NEWTON and KEILL. These papers were published in 1712, under the title of *Commercium Epistolicum*. 8vo.

m In the eloquent and comprehensive *Eulogium* upon Dr. DAVID RITTENHOUSE, the late President of the American Philosophical Society, pronounced by Dr. RUSH, at the request of the Society, there is the following passage: "It was during the residence of our ingenious philosopher with his father in the country, that he became acquainted with the science of *Fluxions*, of which sublime invention he believed himself for a while to be the author; nor did he know, for some years afterwards, that a contest had been carried on between Sir ISAAC NEWTON and LEIBNITZ, for the honour of that great and useful discovery. What a mind was here! without literary friends or society, and but two or three books, he became, before he had reached his four-and-twentieth year, the rival of the two greatest mathematicians in Europe."

Within the period under consideration several new and valuable branches of mathematics, now in use, have been either wholly discovered, or placed on a footing, in a great measure, if not entirely, new. It will be proper briefly to mention some of the more important of these.

In 1717 Dr. Brooke Taylor invented a new branch of analysis, which he called the *Method of Increments*, in which a calculus is founded on the properties of the successive values of variable quantities, and their differences or increments. This method is nearly allied to Newton's doctrine of *Fluxions*, and arises out of it; insomuch, that many of the rules formed for one serve also, with little variation, for the other. By means of the Method of Increments many curious and useful problems are easily solved, which scarcely admit of a solution in any other way. It is, particularly, of great use in finding any term of a series proposed, and also in finding the sums of a series given. In 1763 an ingenious and instructive treatise on this new method was published by Mr. Emerson, who threw further light upon it. The *Differential Method* of Mr. Stirling, which he applied to the summation and interpolation of series, is of the same nature with the Method of Increments, but not so general and extensive.

In 1724 M. Lagny, of France, discovered a new mode of measuring angles, which he denominated *Goniometry*. By means of this method he was enabled to ascertain the measure of angles, without the use of either scales or tables, and with great exactness; a method which exceedingly abbreviated, or rendered wholly unnecessary, many tedious calculations.

In 1746 the Rev. Dr. Stewart, of Scotland, published new and elegant *Theorems*, of great value to the mathematician, by which he extended

the application of geometry to many problems, to the solution of which the Algebraic Calculus had been alone supposed adequate.

About the year 1758 the invention of a new branch of the analytic art, under the name of the *Residual Analysis*, was published by Mr. LANDEN, of Great-Britain. By means of this new operation he enabled the mathematician to solve a variety of problems, to which the method of fluxions had usually been applied, in a way entirely original, and by a process more simple, natural, and elegant, than formerly. He applied this method to drawing tangents, and finding the properties of curve lines, and to the solution of many curious and difficult problems, both in mechanics and physics.

The invention of the *Antecedental Calculus*, a new method of geometrical reasoning, first published in 1793, by JAMES GLENIE, Esq. of North-Britain, also deserves some notice. This is a branch of general geometrical proportion, or universal comparison, derived from an examination of the antecedents of ratios, having consequents, and a standard of comparison given, in the various degrees of augmentation and diminution which they undergo by composition and decomposition. This method proceeds without any consideration of motion or of time, but is, notwithstanding, in the opinion of the inventor, applicable to every purpose to which the celebrated doctrine of fluxions has been or can be applied.

The doctrines of *Tontines*, *Annuities*, and *Reversionary Payments*, were first reduced to system, and brought into use in the eighteenth century. Dr. HALLEY, of Great-Britain, and DE MOIVRE, of France, were among the earliest cultivators of this department of mathematical science. It was afterwards much improved and extended by the successive labours of SIMPSON, PRICE, WEBSTER,

MORGAN, and MASERES, of Great-Britain; by DEPARCIEUX, of France; and by many others, in various parts of Europe.

About the middle of the century under review, and for some years afterwards, flourished the celebrated EULER, a native of Switzerland, and one of the greatest mathematicians, and most excellent men of the age in which he lived. He invented the calculation by *Sines;* he carried to new degrees of perfection the *Integral Calculus;* he did much to elucidate the theory of the more remarkable *Curves;* he contributed greatly to simplify and extend the whole system of *Analytical operations;* and may be said to have thrown new light upon almost every part of mathematical science.[n]

Besides those branches of mathematics which are entirely the growth of the last age, almost every part of this science has been extended and improved within the same period. Of a few of these some transient notice will be attempted.

Since NEWTON published an account of his celebrated method of *Fluxions*, this curious part of mathematical science has received new light, and been carried to new degrees of extent, simplicity

[n] LEONARD EULER was born at Basil, in 1707, and died in 1783, in the 76th year of his age. The mathematical genius and erudition of this man were truly wonderful. No individual of the eighteenth century can be compared to him for the number and value of the discoveries which he made in this branch of science, and for the improvements of which he was the author. His publications are numerous; and there is scarcely a department of mathematics on which he has not thrown some new light, or to which he has not made some important additions. On every subject which he undertook to investigate, he displayed a vigour, a penetration, and a comprehensiveness of mind, which entitle him to a place in the first rank of philosophers. EULER was not less distinguished for the excellence of his moral and religious than for the greatness of his intellectual character. To singular probity, and great social amiableness, he added the piety of an eminent christian. He was a warm and active friend to religion, fervent in his devotions, and exemplary in his attention to all public and private duties. If ever he felt indignation against any particular class of men, it was against the enemies of christianity, especially against the apostles of infidelity. He published a valuable work in defence of revelation, at Berlin, in 1747.

and refinement. For these improvements we are indebted to TAYLOR, CRAIG, MACLAURIN, EMMERSON, LANDEN, SIMPSON, and WARING, of Great-Britain; to CLAIRAUT, NICOLE, D'ALEMBERT, CONDORCET, DE LA CROIX, and DE LA GRANGE,[o] of France; to MANFREDI, of Italy; to PACASSI, a nobleman of Germany; and to none, perhaps, more than to the great EULER, whose work on the *Integral Calculus*, or the *inverse method* of Fluxions, may be considered as holding the first rank on the subject of which it treats.

The principles of *Algebra* have received important additions, and been more satisfactorily displayed during this period, than by the mathematicians of former times. Of this department of mathematical science the most distinguished cultivators were STIRLING, SIMPSON, and WARING, of Great-Britain; the BERNOULLIS, CRAMER, and EULER, of Switzerland; and CLAIRAUT, BEZOUT, LAGNY, DE LA GRANGE, and DE LA PLACE, of France.

It may be asserted that in almost every branch of what is called *Modern Analysis*, much new light, and many curious refinements have been introduced by the mathematicians of the eighteenth century. In the doctrines of *Series*, of *Increments*, of *Differences*, of *Infinitesimals*, &c. great ingenuity has been successfully employed in modern times. And the application of these to astronomy, and other branches of philosophy, may be considered as forming a grand æra in the history of science. For many of these improvements the public is indebted to several of the mathematicians men-

o M. LA GRANGE has lately presented to the world a very important work, entitled, the *Theory of the Analytical Functions*, in which he is supposed to have shown, that every thing hitherto called *Fluxions*, or the *Differential Calculus* (the phrase chiefly used on the Continent of Europe to express Fluxions), whether according to the method of NEWTON or LEIBNITZ, may be reduced to the ordinary calculations of fine quantities.

tioned in the last paragraph; to whose names may be added those of Baron MASERES, of Great-Britain, and of D'ALEMBERT, VANDEMONDE, and ARBOGAST, of France.

The doctrine of *Logarithms* has also been, in the course of the last century, in several respects, improved. New methods of calculating logarithmic tables have been given by SHARPE, TAYLOR, JONES, DODSON, REID, our illustrious countryman Dr. RITTENHOUSE,[p] and last of all Mr. BONYCASTLE. Besides the labours of these great mathematicians the subject of logarithms generally has been more fully and happily illustrated than before, by the several learned works of LEIBNITZ, WOLFIUS, KEILL, MACLAURIN, and SIMPSON.

Several of the higher branches of *Geometry*, particularly the doctrines of *Curves*, *Conic Sections*, &c. have been cultivated with great diligence, during the period under review, and carried to higher degrees of precision and refinement than in any preceding age. Among many who are entitled to much honour for their contributions to this class of modern improvements, it will be proper to select CLAIRAUT, L'HOSPITAL, MAIRAN, MACLAURIN, EMERSON, CRAMER, MURDOCH, HAMILTON, GUARINUS, EULER, ROBERTSON, and GLENIE. To attempt an enumeration even of the principal improvements which these, and many other illustrious mathematicians, have conferred on this branch of the science, would be to travel far beyond the necessary limits of this chapter. The improved state of *Algebra*, and of the *Fluxionary* calculus, and the progress which has been made within a few years past, in the subtleties of *Analysis* in general, have brought the more sublime parts of geometry more within the reach of ordinary capacities, and

p See *Transactions of the American Philosophical Society*, vol. iv.

by their means greatly multiplied the cultivators of this department of mathematical science.

But this is not all; even those branches of mathematics in which no great discoveries have been made, and upon which no signal light has been thrown within the last age, have yet received improvements of a less interesting and brilliant kind. Former discoveries have been extended; old doctrines have been simplified and refined; neater, shorter, and more lucid ways of arriving at the same results have been devised; perspicuous, elegant, and comprehensive theorems have taken the place of those which were more prolix and obscure; and many subtleties and refinements suggested by the philosophers of the preceding age, but not sufficiently developed by them, have been clearly and satisfactorily unfolded.

It is, also, worthy of notice, that in addition to all the improvements which have taken place in mathematical science, as such, it has been applied to many objects, during the last age, to the illustration and accomplishment of which it had never before been directed. A great number of difficult and most interesting problems in astronomy have been resolved by the *Analytic Method*, first applied to this object by Euler. His calculations, by this method, of the perturbations of the earth's orbit, and of the theory of the moon, may be regarded as models of simplicity and beauty. The same illustrious mathematician also first introduced analysis into the doctrines of the *motion of fluids*; and by this means threw great light on the hydraulic principles and laws. Mr. Æpinus, of Petersburgh, before mentioned, has made an ingenious attempt to reduce the mysterious phenomena of *Electricity* and *Magnetism* to the regularity of algebraical calculation. M. De Lisle, of France, has endeavoured, with no small degree of

success, to form a new system of *Mineralogical Characters*, on the principles of geometry; and M. Hauy, of the same country, has given a most elaborate and plausible system of doctrines on *Crystallization*, which all proceed upon fixed mathematical rules.

To this chapter belongs some notice of the attempts which were made, during the period under consideration, to fix on an universal and uniform *Standard of Measure*. Such a standard has been considered a grand desideratum, ever since men began to speculate on subjects of this nature; but probably in no former period was it ever an object of so much attention, and of such diligent research, as in that which we are now reviewing. And though none of the attempts to obtain a standard of this kind have been attended with complete success, yet several of them were so ingenious, and engaged so much of the inquiry of scientific men, that they ought not to be passed in silence.

Huygens, the celebrated Dutch Astronomer, about the middle of the seventeenth century, seems to have first proposed the length of a *Pendulum* vibrating in a given time, as a standard of measure. He proposed to take a pendulum that should vibrate seconds, to measure it from the point of suspension to the point of oscillation, and to assume the third part of such a pendulum, under the denomination of an *horary* foot, as a standard to which the measure of all other feet might be referred. In 1779, Mr. Hatton, of Great-Britain, undertook to improve on the principle of Huygens, by applying a moveable point of suspension to one pendulum, so as to produce the same effect that would result from the use of two pendulums, the difference of whose lengths was the intended measure. Mr. Whitehurst, also of Great-Britain, considerably improved upon this idea, in his tract

on the subject, published in 1787.[q] His plan is to obtain a measure of the greatest length that conveniency will permit, from two pendulums, whose vibrations are in the ratio of 2 to 1, and whose lengths coincide with the English standard in whole numbers. A further improvement in the mode of employing this instrument as a standard of measure is, to make use of a pendulum without a bob, or a uniform cylindrical rod, which, in a given latitude, at a certain height above the surface of the ocean, and at a certain temperature, shall vibrate in a given time. The use of a pendulum of this kind, it is believed, was first proposed by Mr. JEFFERSON, now President of the United States, in his report to Congress, on the subject of weights and measures, while Secretary of State, soon after the establishment of the federal government.[r] It is supposed that this last mentioned standard is preferable, both in simplicity and accuracy, to all others.

The attempt made in France, within a few years past, to form a standard of length, weight, and capacity, by measuring a certain number of degrees on a great circle of the earth, is generally known. This plan is considered, by good judges, as having some important advantages; though in simplicity and practicability it is certainly inferior to the one last mentioned.

The last century is also eminently distinguished for the production of various kinds of *Tables*, which are of the utmost importance to the mathematician, particularly in giving facility and precision to his calculations. Such of these as pertain immediately to astronomy were mentioned in a former chapter.

q *An Attempt towards obtaining invariable Measures of Length, Capacity and Weight, from the Mensuration of Time.*

r Mr. JEFFERSON does not claim the merit of this invention; it was communicated to him by Mr. ROBERT LESLIE, an ingenious watch-maker of Philadelphia.

Besides these may be enumerated the tables of *Logarithms*, of *Sines*, *Secants*, and *Tangents*, of *Difference of Latitude and Departure*, of *Meridional Points*, of *Loxodromic* or *Rhumb Lines*, all of which, and many more, have been brought to a degree of perfection, during this period, which was never before known. The tables more particularly entitled to honourable mention are those of SHERWIN, SHARPE, GARDNER, and TAYLOR, of Great-Britain; of VEGA, of Germany; and of JAMBERT, CALLET, and DE LALANDE, of France.

To give an account, in detail, of the various inventions and improvements which have taken place with respect to *Mathematical Instruments*, during the last age, would exceed the limits assigned to the present review. Some of these have been already mentioned in another place; and many more will readily occur to every reader, whose mind is conversant with objects of this nature. It is sufficient to say that they are numerous and important. The accuracy of construction, the elegance of workmanship, and the ease and expedition of manufacture which modern artists have attained, are equally wonderful, and honourable to the century under consideration.

The science of mathematics has been but little cultivated in the United States during the period under review. Our country, indeed, has been by no means deficient in the production of mathematical genius; but the state of society, and the particular situation of most of those who might have distinguished themselves in this department of knowledge, have prevented that devotedness to the higher branches of mathematics which is necessary to the attainment of excellence, or to accomplish improvements. Still, however, some small productions of this kind, occasionally laid before the public in the *Transactions* of our learned

Societies, afford a very respectable specimen of the talents and erudition of our countrymen, and hold up to view several names with distinguished honour.[s]

CHAPTER VII.

NAVIGATION.

NAVIGATION, considered both as an art and a science, was greatly advanced during the late century. This advancement was owing to a variety of circumstances, which are worthy of being transiently noticed in the present sketch.

The *Construction of Ships* has received, in modern times, very considerable improvements. That method of building which is favourable to *rapid sailing*, has been, for a number of years, gaining ground, in place of the old method, in which *capacity* was chiefly consulted. New and advantageous plans of *rigging* vessels have been adopted, and better modes of working them than were formerly in use. In the science of naval architecture, and of navigation generally, perhaps no individual has done more to useful purpose than EULER, of whose ingenious and excellent labours, in several departments of science, we have had frequent occasion to speak. In consequence of his celebrated publications on this subject, the mathematicians of France were incited to study the

s The first volume on the higher branches of the mathematics ever presented to the public by a native American, made its appearance in the course of the current year (1802), under the title of *Essays, Mathematical and Physical*, by JARED MANSFIELD, of New-Haven, Connecticut. This writer displays a degree of mathematical genius and erudition which does honour to himself and his country.

theory of ship-building, by which means nautical science in that country made remarkable progress. A taste for the same species of inquiry afterwards began to grow in Great-Britain; and under the auspices of the government of that country, and various public societies, has since produced many important improvements.

In estimating the revolutions which took place in naval architecture in the course of the last age, perhaps few are more signal than the great increase in the *dimensions* of ships of the same rate. Ships of war, in particular, are now generally a fourth, and, in many cases, a third larger than vessels of the same number of guns were at the beginning of the late century. In this augmentation the naval architects of France took the lead, and have gone the greatest lengths; the British followed their example, and have carried every thing which relates to the construction and management of ships to a great degree of perfection.

While modern ships are larger than the ancient, they are at the same time more light and simple in their structure. The cumbrous and useless ornaments which the false and unphilosophical taste of preceding ages employed, have been laid aside; and, in general, those principles of architecture adopted which combine the advantage of easy management with the greatest burden.

The *Mariner's Compass*, though it has been in use for several centuries, was attended with great imperfections and inconveniencies until a few years ago, when Dr. Gowin Knight, of Great-Britain, in consequence of his invention of *Artificial Magnets*, was enabled considerably to improve this inestimable instrument. The compasses made by him were found to exceed, in regularity and exactness, all those which had been constructed before his time. After him further im-

provements of importance were made by Mr. SMEATON, and Mr. M'CULLOCH, also of Great-Britain. The complete *Azimuth Compass* is one of the most valuable presents which modern genius has made to navigators.

The compass is scarcely of more importance to the mariner, than the celebrated invention of the *Quadrant*, commonly ascribed to Mr. HADLEY, of Great-Britain, but of which the honour really belongs to Mr. GODFREY, a philosophic artist of Philadelphia. To which may be added the numerous improvements of this instrument, some of which were mentioned in another place; to say nothing of many others, under the names of *Sectants*, *Octants*, &c. constructed on like principles, and for similar purposes.

Almost all the methods now in use for finding the *Longitude*, whether by means of *Lunar Observations*, the position of *Jupiter's Satellites*, or of well constructed *Time-keepers*, were first brought into general use during the last century. The rise, progress, and authors of these several discoveries and improvements were briefly detailed in a former chapter. The important place which they hold in the annals of navigation is too generally understood to require formal elucidation.

The invention of *Ephemerides*, or *Nautical Almanacks*, is another important event which belongs to the century under review. They were first published for the use of mariners, by M. DE LA CAILLE, about the year 1755. Dr. MASKELYNE, in England, followed his example, and first published them in that country, about the year 1767. The effects of these almanacks in advancing the art of navigation is well known. Their influence in promoting the *Lunar* method of finding the longitude is worthy of particular remark. The extreme facility with which that operation, for-

merly so tedious and difficult, is now performed, even by common seamen, deserves to be noticed as a distinction of the age under consideration.

The great augmentation in the number of *Maps* and *Charts*, and the manifest improvements in their construction, accuracy, and elegance, may also be mentioned among the circumstances, in modern times, which have contributed to the advancement of navigation. The degree in which these improvements have promoted the safety, the comfort, and the expedition of late voyages, is scarcely within the reach of ordinary calculation.

But there are few modern improvements in the art of navigation more gratifying to humanity than the remarkable and very successful attention to the *Health of Seamen*, which characterizes the conductors of late voyages. The names of those who distinguished themselves by devising and bringing into use the most approved methods for promoting this end were respectfully mentioned in a preceding division of this work. The great contrast which the history of ancient and modern voyages presents with respect to the comparative destruction of the health and lives of mariners which they produced, cannot but forcibly arrest the attention of every reader, and exceedingly gratify the benevolent mind. Besides the improvements in diet and regimen on ship-board, to which modern science and humanity have given rise, and which have contributed greatly to preserve the health of seamen, the introduction of *Ventilators* into ships also deserves to be mentioned as an important means of promoting the same object, and, at the same time, for preserving the timber and cargoes of vessels.[t] To these may be added

[t] For the invention of one of the most complete and useful plans for ventilating ships, we are indebted to our ingenious countryman, Mr. Wynkoop, of Philadelphia, whose contrivance for this purpose has received high praise from those who are most competent to judge of its merits.

some notice of the modern improved methods of constructing *Pumps*, and other hydraulic machinery of ships, by which the safety and comfort of navigators are greatly secured.

In addition to the improvements which have been mentioned, some notice might be taken of the various plans for promoting *Sub-marine Navigation*, which have been laid before the public at different times, and by different persons in the course of the last age; of the attempts to construct *Life-boats*, for the safety of mariners in cases of extremity; of the improved methods which have been invented for facilitating the guidance of ships on the ocean, and for measuring their progress. But to give an intelligible enumeration of these and of many other modern improvements in navigation would lead to a minuteness of detail inconsistent with the plan of the present sketch.

Besides many ingenious individuals to whom mariners are indebted for patronizing and aiding their art, much is also due to some learned and other *societies*, for their useful exertions to promote the same end. But perhaps to no public bodies will the annals of modern navigation be found to ascribe more than to the *Board of Longitude*, and the *Board of Admiralty* of Great-Britain.

From the concurring influence of all the considerations above stated, enterprising men have learned, within the eighteenth century, to traverse the most distant seas, with a degree of ease, confidence and expedition, wholly unknown in any former age. A voyage from Europe or America to India, is now performed in half the time that it cost an hundred years ago; and even a voyage round the world is considered at present as an undertaking scarcely more formidable than a voyage from America to Europe at the beginning of the century in question.

But few things distinguish the eighteenth century more than the extension and the improvements of the system of *Inland Navigation.* Canals, for the conveyance of small vessels, through districts of country not favoured with rivers adequate to the purpose, have been more or less in use for many ages. But, during the last age, the number of these canals has been astonishingly multiplied; various improvements in the construction of them have been adopted; and they have become an incalculable source of convenience, comfort, and wealth.

Very early in the eighteenth century the cutting canals in the empire of Russia was undertaken by command of PETER the Great, and prosecuted on a scale of wonderful extent. That celebrated monarch was led to this undertaking by observing the great utility of canals in Holland, by means of which a low and marshy tract of country was converted into a rich, populous, and fruitful territory. Though the Emperor did not live to see the completion of his plans, yet, under his auspices, they were carried on to a considerable length, and continued with great zeal, by his successors, especially by the late Empress: insomuch that there is, probably, " no part of the world where inland navigation is carried through such an extent of country as in Russia; it being possible, in that empire, to convey goods by water, *four thousand four hundred and seventy-two miles*, from the frontiers of China to Petersburgh, with an interruption of only sixty-six miles; and from Astracan to the same capital, through a space of *one thousand four hundred and thirty-four miles;* a tract of inland navigation almost equal to one fourth of the circumference of the earth!"[v] The number of vessels employed on

[v] See PHILLIPS's *History of Inland Navigation*, 4to. chap. iii.

the different canals of Russia, and the amount of merchandize, of various kinds, for which they furnish means of transportation, almost exceed the bounds of credibility.

Since the undertaking of the Russian Emperor, similar improvements have been projected and executed in Sweden, Denmark, France, and Spain; from which very important advantages have resulted to those several countries, and from which many more, by due attention, might be produced. The first navigable canal cut in Great-Britain was that undertaken by the Duke of BRIDGEWATER, and completed, at his expense, in 1759, for the purpose of forming a communication between his coal works, at Worsley, and the city of Manchester. This work was planned and executed by Mr. JAMES BRINDLEY, an engineer of singular talents, and the author of the present most approved system of canal navigation. His great and original genius, the force of mind which he displayed in surmounting the difficulties which were presented in his course, and the various improvements which he suggested in the formation and management of canals, have been, very deservedly, the subjects of much eulogy by every succeeding artist. After Mr. BRINDLEY's first successful attempt, canals became popular in Great-Britain and Ireland, and a considerable number, some of them on a very large scale, were undertaken in different parts of those countries. BRINDLEY, who died in 1772, was succeeded by Mr. SMEATON, Mr. WHITWORTH, Mr. WATT, and others, who eminently distinguished themselves as engineers in the same line.

Attempts of a similar kind have been made in the United States; but neither on so large a scale, nor hitherto with so much success, as in Europe. The trials, however, which have been made in the States of Connecticut, New-York, Virginia, and

South-Carolina, bid fair to be highly useful, and to afford an honourable specimen of American enterprise. In several of the other States plans of the same kind have been formed, and partly executed; and there is every probability that a few years more will present us with a large amount of this species of improvement in many parts of our country.

CHAPTER VIII.

AGRICULTURE.

NO art is of more ancient date than this. It employed our first parents in Paradise; and has been more or less an object of pursuit in all ages. Like almost every other object of human attention, however, it has undergone numberless revolutions of decline and revival, in different periods, and among different nations. In Egypt, in Palestine, in Greece, in Persia, and in the Roman Empire, this art, successively, rose into importance, flourished under various wise encouragements, and gradually declined with the learning, taste, and industry of those respective countries. From the time of CONSTANTINE the Great, to the beginning of the seventeenth century, the annals of agriculture furnish little worthy of attention. About the latter period, in consequence of many laudable efforts made by men of influence, and the publication of several valuable works on the subject, this art began to revive in France, and in Flanders. The inhabitants of those countries endeavoured, for a considerable time, to conceal the means which they used for improving and increasing the productiveness of their lands. Whoever, therefore,

became desirous of receiving instruction in their method of husbandry, was under the necessity of visiting their country, and observing for himself. We are told that the French, at this period, were in the habit of using nine different sorts of manures; but of the nature of each we are not informed. It is also said that they were the first people, among the moderns, who ploughed in green crops, for the sake of fertilizing the soil; and who confined sheep in sheds at night, for the purpose of increasing the amount of their compost manure.[u]

Agriculture next revived in Great-Britain. To this, there is reason to believe, the writings of Sir HUGH PLATT very much contributed. He discovered, or brought into use, many new kinds of manures, and, perhaps, contributed more to the improvement of the art of cultivating the earth, than any other individual of the age in which he lived. He was succeeded by HARTLIB, a writer much esteemed in his day, but by no means equal to his predecessor. The exertions of these men, and others of less note, together with the peculiar circumstances of the nation, prompted gentlemen of the greatest influence to encourage agriculture, to regard it as the most certain and productive source of wealth to their country, impoverished by preceding wars, and to promote its improvements with zeal. But this flourishing era of husbandry was of short continuance. At the Restoration, the country gentlemen relapsed into negligence and dissipation; surrendered the rural honours which they had before sought with so much eagerness, and left them to be pursued by the least enlightened part of the community.

Happily, however, this decline, like the preceding revival, was also of short duration. Mr.

[u] See Encyclopædia, art. *Agriculture.*

Evelyn was the first writer by whom his countrymen became again inspired with just sentiments on this subject; and by whose exertions agriculture was enabled, once more, to claim its former dignity. Indeed, after the peace of Aix la Chapelle, in 1748, most of the nations of Europe, by a kind of tacit consent, applied themselves to the study of this art, which has been, from that period to the present, gradually increasing in extent and importance, and assuming more of the regular and consistent aspect of a science.

In the course of the last fifty years many capital and most useful improvements have been introduced into agriculture. Individuals of wealth and taste, and learned societies have embarked in plans for its encouragement, with a degree of enlightened zeal which was never before displayed. Many ingenious and judicious publications have suggested new plans and objects of cultivation, have diffused a knowledge of well directed experiments and observations, and have excited a general spirit of emulation in pursuing this kind of improvement. Philosophers, in this century, for the first time, have united with the practical cultivators of the earth, in exploring new means of increasing the fertility of the soil, and, consequently, of increasing the wealth and the comforts of man.

In zeal for agricultural improvements, and in the success with which they have been pursued, during the last age, Great-Britain certainly holds the first place. Next to her stands France, and afterwards come in succession, Italy, the German Empire, &c. In Holland, Spain, Portugal, Turkey, and Russia, improvements have been few, and slowly advancing. It is true that even in the last mentioned countries, some efforts have been made, by associations and otherwise, to promote the best methods of cultivating the earth; but various

circumstances have hitherto conspired either to weaken these exertions, or render them, in a great measure, ineffectual. The commercial spirit of Holland has long driven from her view every general plan of agricultural enterprise, and several of the other nations which were mentioned, fixed in inactivity, under the congealing influence of ignorance and slavery, are equally unacquainted with, and indifferent to the most important and indispensable foundations of public prosperity.

Among the memorable events in the annals of agriculture, pertaining to the eighteenth century, may be mentioned the mode of tillage invented and proposed about the year 1760, by Mr. JETHRO TULL, of Oxfordshire, in England, and usually denominated the *Horse-Hoeing* and *Drill Husbandry.* The objects of his plan are, to turn up, break and pulverize the soil more deeply and thoroughly than by the usual means before employed, and to deposit the grain in the earth in such regular rows as to admit of the *horse-hoeing* cultivation being applied to it in the course of its growth. The introduction of TULL's system is considered as forming a grand era in agriculture, not only on account of its own intrinsic utility, but also because of the numerous improvements to which it indirectly led.

Essential service has been rendered to agriculture by the inquiries of modern philosophers into the *Physiology of Vegetables.* These inquiries have led to new and important conclusions, respecting the food of plants, and the best means of promoting vegetation. On this subject much valuable information has been communicated to the public by HALES, HILL, WALKER, and DARWIN, of Great-Britain; by DU HAMEL, DES FONTAINES, BROUSSONET, and HASSENFRATZ, of France; by INGENHONZ, VAN HUMBOLDT, and JACQUIN,

of Germany; and by BONNET and SENNEBIER, of Geneva.

The eighteenth century is remarkable for the numerous improvements which, in the course of it, have been introduced into agriculture, through the medium of *Chemistry*. Indeed, the modern application of chemical doctrines to the cultivation of the earth, may be considered as forming a grand era in the history of science. In this application of chemical philosophy many persons have distinguished themselves, and rendered important service to agriculture. Among these the Earl of DUNDONALD is entitled to particular notice.[w] He had the honour of publishing one of the first formal treatises on this subject. He has been followed by many others, who have pursued the inquiry much further, and with great success.

The nature and advantages of particular *Soils* have been, more or less, the objects of inquiry in all ages. But inquiries of this kind, in the couse of the eighteenth century, have been more numerous, enlightened and useful than ever before. A number of philosophers, during this period, have made careful analyses of different soils, and by this means threw much new light on the principles of agriculture. Those who most distinguished themselves by investigations of this nature are GIOBERT, BERGMAN, KIRWAN, and PARMENTIER, to say nothing of several others, no less worthy of being respectfully mentioned in the same list.

The last century is also distinguished by the introduction of several new and important *Manures* into general use. Of these it will be proper to take some notice in our rapid course.

The great advantages of *Gypsum* as a manure, were discovered in the year 1768, by M. MAYER,

w See his work on the *Connection of Agriculture with Chemistry*.

a respectable German clergyman.[*] Since that time this substance has been used with much success, not only in Germany, but also in several other parts of Europe, as well as in America; but the manner in which it produces its fertilizing effects, notwithstanding the numerous and diligent inquiries which have been made on the subject, is still far from being satisfactorily unfolded.

The efficacy of *Carbon*, or common *Charcoal*, in promoting vegetation, was first ascertained, a few years ago, by M. HASSENFRATZ, a celebrated French chemist. He found that this substance is an essential ingredient in the food of all vegetables, and that soils are, in general, fertile in proportion to the quantity of it which they contain. The properties and effects of carbon as a manure have been since diligently and successfully examined by various other writers and experimenters on the subject.

The general use of *Marle*, *Lime*, *Chalk*, and various combinations of calcareous matter, as means of increasing the fertility of the soil, is chiefly of modern date. And even with respect to these, and such other manures as were in a degree known and employed in ancient times, the mode of their operation, the best methods of applying them, and the various circumstances which should attend the application, have been incomparably better understood, within a few years past, than in any former period. The most scientific and satisfactory modern writers on manures, in general, are DUNDONALD, MIDDLETON, DARWIN, and TENNANT, of Great-Britain; KIRWAN, of Ireland; PARMENTIER, of France; RUCKERT and VON USLAR, of Germany; and ELLER, WALLERIUS and GYLLENBORG, of Sweden.

* *Transactions of the Royal Irish Academy*, vol. v. p. 196.

The influence of *Light* on growing vegetables has also been investigated with great success by many modern philosophers. Among these HALES, PRIESTLEY, Abbe TESSIER, INGENHOUZ, and SENNEBIER are entitled to particular distinction. From the experiments of these philosophers, it appears that this subtle fluid has a powerful effect on the colour of vegetables; that when exposed to its influence, it enables them to yield pure air; and that it converts many substances, which would otherwise become putrid and offensive, into wholesome food of plants.

The efficacy of *Electricity* in forwarding the germination and growth of plants, was discovered and satisfactorily established by the philosophers of the eighteenth century. It was before remarked that Mr. MAIMBRAY, of Edinburgh, was the first who applied electricity to this object. He was followed by the Abbe NOLLET, Mr. JALLABERT, M. BOZE, and several others, who all formed the same conclusions. Still more recently the well devised and indubitable experiments, of Messrs. D'ORMOY, ROZIER, CARMOY, and BARTHOLON, all of France, have thrown additional light on the subject, and substantially confirmed the results of preceding experiments.

The influence of various *Factitious Airs* in hastening and retarding the progress of vegetation, is a branch of agricultural inquiry peculiar to the eighteenth century. On this subject the successive experiments of Dr. HALES, Dr. PRIESTLEY, Lord DUNDONALD, Sir FRANCIS FORD, and Dr. DARWIN, of Great-Britain; of HASSENFRATZ, and several other French Chemists; and of JACQUIN, VON USLAR, and VON HUMBOLDT, of Germany, have furnished very interesting and important information.

Besides the new substances employed for pro-

moting the fertility of soils, and hastening the process of vegetation, the last age is also distinguished by the introduction of a number of new and important objects of culture.

Among these scarcely any is more worthy of attention than the *Potatoe*. This valuable root, which is generally supposed to have been found originally in North-America, was not much cultivated in Europe till the close of the seventeenth century; and even then was chiefly confined to Great-Britain and Ireland, and seldom seen except in gardens, as a curiosity. How much it has grown in importance, and in the extent of its cultivation, since that period, both in our own country, and in almost every part of the civilized world, is well known. Instead of being deemed, as it once was, a food fit only for the lower classes of society, it has come into general and almost indispensible use among all ranks. It has added another to the list of cheap, simple and wholesome articles of nutriment, and furnishes an additional barrier against famine, beyond what our ancestors enjoyed.

No less important is *Maize*, or *Indian Corn*, another article, which, as an object of general culture, may be considered as in a great measure peculiar to the century under review. This valuable grain was little cultivated, at the beginning of the century, excepting in America. Since that time it has not only become an object of more general and uniform attention in our own country, but it has been introduced with success into the South of Europe, and several other temperate climates, where it was before unknown, and has been constantly gaining ground, both in reputation and utility. The ease with which this species of corn is cultivated; its great productiveness; its exemption from injury by those seasons and insects which destroy other grains; its singularly whole-

some and nutritive qualities; and the great variety of excellent preparations of which it is susceptible, render its extended cultivation one of the most distinguished and useful agricultural improvements of the age.

The cultivation of the *Sugar Cane*, in the American islands, though not wholly, is in a great measure, an improvement of the eighteenth century. The great importance of this plant, in various points of view, renders the increase of its culture, in any part of the world, an object worthy of particular regard.[y] Connected with the sugar cane is the *Sugar-Maple*, of the United States, which has lately grown into an article of consequence. An estimate may be formed of the value of this tree, as a means of supplying ourselves and other nations, with a salutary food, by perusing the various publications which, within a few years past, have been made on the subject, particularly those of Mr. NOBLE and Dr. RUSH. The discovery that sugar of an excellent quality may be extracted in large quantities from the *Beet Root*, was made a few years ago, by Mr. ACHARD, of Germany, whose experiments have been considerably aided, and carried to a greater length by M. NOLDECHEN, of the same country.

The introduction of the culture of *Rice* into the United States, to any extent, is one of the honours of the period under consideration. In 1693 a vessel from Madagascar brought some of this grain to Charleston, in South-Carolina. The Captain gave such a description of it to some of the inhabitants, that they determined to try the cultivation of a

y In 1700 the quantity of sugar imported into England amounted only to 481,425 cwt. but in 1790, the consumption of this article, in the same country, had increased to 166,573,344 lbs. The demand for it has been rapidly growing through the whole century, and it is now to be found in almost every hovel, the tenant of which has the means of purchasing it. See RAMSAY's *Review*, p. 32.

vegetable which appeared congenial to their soil. For a number of years they made little progress in it, not properly understanding the nature of the soil, or the means of culture favourable to its growth, and having little prospect of commercial advantage from it, to animate their exertions. But since the restraints and discouragements of colonial servility have been taken off, the cultivation of this grain has become much more extended, not only in South-Carolina, but also in North-Carolina and Georgia, and is now to be regarded as a principal staple of those States.[z]

Cotton was first cultivated in America, to any extent, in the century under review. As it happened with respect to Rice, the original introduction of this article was many years prior to its becoming an object of much attention and importance. But the advantages which have accrued particularly to South-Carolina and Georgia, within a few years past, from cotton having become a principal object of agriculture in those States, are truly astonishing. It is confidently asserted, that in some parts of those States, the amount of wealth has more than trebled within the last five or six years, from this source alone.

The cultivation of *Indigo* in America also commenced within the period of the present retrospect. This plant, which is a native of Hindostan, had an American residence first assigned to it in Mexico and the Leeward Islands.[a] Its introduction into South-Carolina took place, it is believed, about the beginning of the eighteenth century, or not long afterwards. But though this vegetable a few years ago held an important place among the ob-

z Attempts have been made on a small scale, to cultivate *Rice* in the State of *Maryland*, and not without success; but the object has not been pursued to any profitable extent. See Bordley's *Husbandry*.

a Raynal's *History of the East and West-Indies*.

jects of culture in that southern country, it has lately engaged much less attention than formerly.

The practice of *naturalizing foreign vegetables*, in different soils, has been practised on a more extensive scale, during the eighteenth century, than in any preceding period. Amidst all the labour and care of the ancients to improve agriculture, they scarcely enjoyed, in any degree, the advantage of witnessing experiments of this nature. Each country was in a great measure confined to its own indigenous productions. This continued, for the most part, to be the case till the beginning of the century under consideration. Since that time the choicest vegetable productions of different climates have been transplanted to other and distant regions; and great advantages to agriculture have arisen from this source.[b]

The cultivation of *Fruit trees* has become an object of increased attention, and has received many improvements in the course of the last age. New and delicate modes of propagating fruit trees have been discovered; new and useful methods of improving the flavour, and preserving the soundness of fruit have been adopted; and this branch of husbandry, in general, rendered more important and profitable than formerly. Among many who have distinguished themselves by rendering service to this branch of agriculture, may be mentioned Du Hamel, Bradley, Knight, Speechly, Hitt, Walker, and very lately Forsyth, who is said to have improved greatly on the labours of all who had gone before him.

From the increased attention to agriculture and gardening, in the course of the last age, has arisen

[b] Among many other instances which might be adduced, it is believed that the *Bread-fruit-tree* was never seen either in Europe or America till toward the close of the eighteenth century. The late laudable, and, in a degree, successful exertions of the British government to naturalize this tree in their American Islands, are worthy of high praise.

an important fact, which the friend of human happiness must contemplate with pleasure, viz. a great increase in the use of vegetable food. In the seventeenth century animal food constituted an undue proportion of the nutriment of man. In the eighteenth some progress has been made towards the correction of this error, though this desirable end is yet far from being fully accomplished.[c]

It would be difficult, in truth, to mention a single principle or practice in agriculture which has not been more or less improved within the period under consideration. The advantages and defects of particular *soils;* the efficacy of *manures;* the *rotation of crops;* the improvement of the *implements* of husbandry; and the almost infinite variety of inquiries connected with agricultural pursuits, have been investigated with great diligence, and have received much elucidation in the course of the last age. For a great amount of useful information on these subjects, and for multiplied improvements in agriculture generally, the public is indebted to Mr. MILLER, Mr. ELLIS, Mr. MARSHALL, Mr. ARTHUR YOUNG, Mr. ANDERSON, Mr. COKE, Sir JOHN SINCLAIR, and many others, of Great-Britain; to Messrs. DU HAMEL, CHATEAUVIEUX, TOURBILLY, ROZIER, TESSIER, BROUSSONET, TILLET, and PARMENTIER, of France; besides many others, equally entitled to notice, in other parts of Europe.

Probably the most complete and scientific work on this subject now in possession of the public, is the *Phytologia*, or the *Philosophy of Agriculture and Gardening*, by Dr. DARWIN, of Great-Britain. In this work the learned and ingenious author has

c Sir JOHN PRINGLE states, on the authority of Mr. MILLER, the keeper of the botanic garden at Chelsea, and author of the *Gardener's Dictionary*, that the quantity of vegetables used in and near London, at the time of the Revolution, in 1688, was not more than *one sixth* of what was used in the same place in 1750. See RAMSAY's *Review*.

introduced a great amount of curious information, and of judicious principles and precepts; but its value is, doubtless, diminished by the whimsical opinions, on a variety of subjects, which he so frequently displays. Perhaps the fault most worthy of notice is, the ridiculous extreme to which the author presses the analogy between the animal and vegetable tribes, and the principles of vegetation thence deduced. In a poem this would be excusable; hence the *Loves of the Plants* may be defended; but in a sober, didactic, philosophical work, it is much better calculated to amuse than to instruct.

While the principles of tillage have been better understood, and the knowledge of them more extensively diffused, within a few years past, numerous and very important improvements have taken place in the art of selecting and rearing *Cattle*, and other animals which fall under the care of the husbandmen. The attention paid to the breed, health, growth, and general economy of the various kinds of stock, within the last half century, in many parts of Europe, and particularly in Great-Britain, has not only been greater than ever before, but has also been crowned with a degree of success which would once have been thought scarcely possible.

Connected with the improvements in the rearing of cattle above stated, are the new articles of *Provender* for cattle, which have been added, within the last half century, to those formerly in use. For this addition mankind are, probably, indebted to none more than to LINNÆUS, and his disciples in Sweden; the Abbé TESSIER, of France; and Mr. ANDERSON, of Great-Britain, whose writings on the subject are among the most learned, judicious, and useful extant.

Besides the writings of individual authors on

agriculture, and the various subjects connected with it, many facts, discoveries and improvements have been recorded and laid before the public, in the transactions of numerous agricultural *Societies*, formed in almost every part of Europe, and in America. These associations have proposed questions to be brought to the test of experiment and discussion; have offered premiums and honours for encouraging the necessary inquiries; have invited free communications from all classes of citizens; and by these means brought to light many instructive facts and doctrines, which the exertions of detached individuals could scarcely have developed. It is, doubtless, to the influence of these associations that we are to ascribe much of that pre-eminence in agriculture, over all other ages, which the eighteenth century claims.

The improvements which have taken place in the agriculture of the United States, during the last twenty or thirty years, are very great. Our farmers, it is true, are far from having kept pace with their European brethren in enterprise, and the adoption of new and profitable modes of cultivation. Many of them obstinately adhere to practices which have been completely exploded; and neglect others and better, though recommended by the fullest experience. But if much remains to be done, much has also been performed towards the correction of this evil. Within a few years past, societies for the promotion of agriculture have been formed in all the principal States in the Union. Gentlemen of learning, observation, and property have zealously embarked in this interesting cause. The adoption of trans-atlantic improvements is gradually becoming more common; and the aspect of a large portion of our country indicates a considerable increase of enterprise and of taste in husbandry. The number of our country-

men who have contributed to the advancement of agriculture by their writings is small. Among these may be mentioned Chancellor LIVINGSTON, Professor MITCHILL, and several other gentlemen, whose valuable communications appear in the transactions of the Agricultural Society of New-York; Judge PETERS,[d] and Dr. LOGAN,[e] of Pennsylvania; and Mr. BORDLEY,[f] of Maryland.

CHAPTER IX.

MECHANIC ARTS.

THE progress of civilized man in the mechanic arts, during the last hundred years, has been astonishingly great. To attempt a review, in detail, even of the principal inventions, discoveries and improvements, which have taken place, during the period in question, in this boundless field for the exertion of genius and enterprise, would swell this section into many volumes. But happily the minds of most readers are so conversant with many of the objects which demand attention, in this department of the present work, that such minuteness of detail is as unnecessary as it is impossible.

The modern discoveries in *Mechanical Philosophy* have led to great and important improvements in the mechanic arts. The subserviency of those discoveries to the progress of many branches of art will readily appear from the perusal of the

d *Agricultural Inquiries on Plaster of Paris*, &c. 8vo. 1797.
e *Agricultural Experiments on Gypsum*, &c. 8vo. 1797.
f *Notes on Husbandry and Rural Affairs*, &c. 8vo. 1799.

chapter which relates to them. That they have contributed, and will probably yet contribute, in a considerable degree, to the abridgement of labour, to the convenience and profit of artists, and to the excellence and beauty of manufactures, is too obvious to require particular explanation.

The great discoveries which the philosophers of the last century made in *Chemistry*, may also be considered as rendering very distinguished service to the mechanic arts. On the manufacture of all *metallic* and *earthen* wares, the improvements in chemistry have shed important light; and indeed to all the arts in the different processes of which heat, solution, composition, distillation, fermentation, and precipitation are necessary, chemical philosophy has furnished valuable aid.

Never were manufactures carried on upon so *large a scale* as during the eighteenth century, especially toward the close of it. The number of hands, and the amount of capitals employed in various branches of manufacture in Europe, may be pronounced, without hesitation, greatly to exceed the largest establishments of any former times.

It may also be asserted, that manufactures in general were never carried on with so much expedition and cheapness, or with so much elegance of workmanship, as at the close of the period under review. It is true, these circumstances have led to an increased *slightness*, and the want of *durability*, particularly in some articles of modern manufacture; but in many more cases, a great improvement in *quality*, as well as in *elegance*, has taken place.

The *division* and *abridgement of labour* were carried to a greater length in the course of the last age than in any preceding period. The influence of both these circumstances in promoting the me-

chanic arts, will be readily appreciated by every intelligent reader.

But besides these general remarks, it will be proper to take notice of some of the principal inventions and improvements of the mechanical kind, by which the last age is distinguished.

The different kinds of machinery for *Carding* and *Spinning Cotton*, which modern times have produced, have proved a source of incalculable advantage to manufacturers, and do honour to the age. Less than forty years ago, the only machine much used for reducing cotton wool into yarn, was the *One-thread-wheel.* Other methods, indeed, had been thought of, and proposed for promoting a more easy and expeditious process; but without any extensive or permanent success. At length, about the year 1767, Mr. JAMES HARGRAVE, an English weaver, constructed a machine, by means of which any number of threads, from twenty to eighty, might be spun at once, and for which he obtained a patent. This machine is called a *Jenny*, and deservedly holds a high place among modern inventions. The astonishing abridgement of labour which it produces has been too much and generally celebrated to require illustration here. Soon after the invention of this machine, Mr. HARGRAVE contrived a new method of *carding* cotton, more easy and expeditious than the old way of carding by the hand, which was now found inadequate to the rapid progress and large demands of the improved mode of spinning. He was succeeded by several other ingenious artists, who laboured with success, and who produced that expeditious plan of carding, by what are commonly called *Cylinder-cards*, which is now so extensively and profitably practised.

The next and most remarkable improvements in this kind of machinery were made by Mr. ARK-

WRIGHT, afterwards Sir RICHARD ARKWRIGHT; also of Great-Britain. He laid before the public his new method of spinning cotton, in 1768, for which he obtained a patent in 1769. In 1775 he also obtained patents for several engines which he had constructed to prepare the materials for spinning. The result of his different inventions is a combination of machinery, impelled by horses, water, or steam, according to circumstances, by which cotton is *carded*, *roved* and *spun* with wonderful expedition, and with great exactness and equality.[g]

The effects produced by these splendid improvements, in extending the cotton manufactures of Great-Britain, and in rendering them a source of national wealth and aggrandizement, are generally known. The number of cotton mills erected within a few years past; the great number of hands to which they afford employment; the immense capitals devoted to them; and their great productiveness, present a spectacle altogether unparalleled in history.

The first British *Calicoes* were made in Lancashire, about the year 1772. The manufacture of *Muslins* was first successfully introduced into that country in 1781. Both these branches of manufacture, which were before chiefly confined to India, have lately gained an extension, and assumed a consequence which must render their introduction a most important era in the history of Great-Britain.

Machines for carding and spinning cotton were introduced into several parts of the United States during the last fifteen years of the century under

g Sir RICHARD ARKWRIGHT was bred a barber; and was, in the early part of his life, in very low circumstances. He rose in fortune and in fame rapidly; and, in 1793, died at his manufactory in Derbyshire, leaving property to the amount of £ 500,000 sterling, or 2,225,000 dollars. HARDIE'S *Biographical Dictionary.*

review. But, like most other enterprises in the manufacturing line, undertaken in our country, they have not been pursued either so extensively or so profitably as could be wished.

In this connection it will be proper to take some notice of two American inventions, for facilitating the making of wool and cotton *Cards*. About sixteen or seventeen years ago, a machine was invented in Massachusetts, for cutting and bending wire in a state completely prepared for *sticking* cards.[h] Before this time the cards used in the United States were imported from Europe. Ever since a sufficient quantity has been manufactured in our own country to supply its demands, and, at a late period, for exportation to a considerable amount. In 1797, Mr. Amos Whittemore, of Cambridge, in Massachusetts, invented a machine, which, by a simple operation, bends, cuts, and sticks card teeth, by the aid of which a dozen pairs of cards can be furnished in less time than was formerly required to make a single pair.[i]

Allied to the inventions above enumerated are the improvements in the art of *Weaving* which modern times have produced. Among these, perhaps none is of more importance than the *Flying Shuttle*, lately introduced by the artists of Great-Britain. Previous to the introduction of this contrivance, when wide cloth was woven it was necessary to employ two or more hands to execute the work. The same task can now be executed by

h Two persons claimed the invention of this machine, viz. Foster and M'Clinch. The latter had his machine first in use, being more of a practical mechanic; but it was said that he had privately obtained a sight of Foster's work, who first planned the machinery. As it is not easy to ascertain the precise truth of this question, so it is of no importance to the public to which of these gentlemen the honour belongs.

i In September, 1799, William Whittemore and Co. commenced the manufacture of cards with this machine, in Cambridge. There are now twenty three machines of this kind in operation at the same manufactory, which are able to furnish *two hundred dozen pairs* of cards, on an average, every week.

one person, and with much more convenience and expedition than formerly.

It was before remarked that *Steam Engines* were scarcely at all known prior to the eighteenth century. To the honour of inventing and perfecting this kind of machinery the artists of Great-Britain are entitled. The honour particularly due to Messrs. NEWCOMEN, BEIGHTON, and WATT, on this subject, has been acknowledged in a former chapter. The force of *Steam* has been applied, during the period under review, to the turning of mills for almost every purpose; and there is no doubt that the machines moved by this agent are the most powerful ever formed by the art of man.[j]

In the erection of *Bridges*, modern artists have displayed unprecedented boldness and enterprise. The first bridge constructed of *cast iron* was produced in the eighteenth century. This was erected over the river Severn, in Shropshire, South-Britain, in 1779, by Mr. A. DARLEY, an ingenious iron-master, assisted by the exertions of Mr. J. WILKINSON, of the same profession. The second *iron* bridge was constructed on a larger scale, over the same river, in 1796, upon a new plan, by Mr. THELFORD. A third, on a still larger and more daring scale, was built over the river Wear, in Durham, a short time afterwards, by ROWLAND BURDON, Esq. To these may be added the *wooden* bridges, of several kinds, and on various new constructions, which have been invented in the course of a few years past, both in Europe

j One of these engines, as improved by Mr. WATT, and employed for draining the deep mines of Cornwall, works a pump of eighteen inches diameter, and upwards of 100 fathom, or 600 feet high, at the rate of ten to twelve strokes, of seven feet long each, in a minute, and with one-fifth part of the fuel that a common engine would take to do the same work. The power of this engine may be more easily comprehended by saying that it can raise a weight equal to 81,000 lbs. eighty feet high in a minute, which is equal to the combined action of 200 good horses. See *Botanic Garden, Additional Notes*, p. 155, New-York edition.

and America, and which have proved sources of great public utility.

In the construction of *Mills*, improvements no less remarkable and important have been made, within the period in question. Of these, some have arisen from the new light lately thrown upon the laws of *hydraulics;* and others from the ingenuity and enterprise of practical artists. The numerous experiments and discoveries, and the learned writings which have been given to the world, in the course of the century, on this subject, by DESAGULIERS, EMERSON, SMEATON, BARKER, and BURNS, of Great-Britain; by BELIDOR, DE PARCIEUX, and others, of France; by BERNOULLI, of Switzerland; by LAMBERT and KARSTNER, of Germany; and by ELVIUS, of Sweden, make a most interesting part of the mechanical history of the age.

Equally worthy of attention are the successive inventions and improvements of modern artists, in the construction of all kinds of *Wheel Carriages.* To enumerate these, and to attempt to give a list of their authors, would be an endless task. Suffice it to say, that the superiority of modern wheel-carriages over those possessed by our predecessors, in lightness, elegance, beauty of form, and convenience, is very great, and constitutes one of the mechanical honours of the age.

In the art of *Coining* several important inventions have been produced, in the course of the last century, which are worthy of being remembered. Probably the most conspicuous and valuable of these is that by Mr. BOULTON, an artist near Birmingham, in Great-Britain. "He has lately constructed a most magnificent apparatus for coining, which has cost him some thousand pounds. The whole machinery is moved by an improved steam-engine, which rolls the copper

for half-pence finer than copper has before been rolled for making money; it works the coupoirs or screw-presses for cutting out the circular pieces of copper, and coins both the faces and edges of the money at the same time, with such superior excellence, and cheapness of workmanship, as well as with marks of such powerful machinery, as must totally prevent clandestine imitation, and, in consequence, save many lives from the hand of the executioner. By this machinery four boys, of ten or twelve years of age, are capable of striking thirty thousand guineas in an hour, and the machine itself keeps an unerring account of the pieces struck."[k]

Several modern improvements in the art of *Printing* deserve a place in this imperfect list. The first worthy of being mentioned is the *Stereotype*[l] plan of printing, which has lately become so fashionable, especially in France. This plan was first invented in 1725, by Mr. GED, a goldsmith, of Edinburgh, who, among other books, printed a very neat edition of *Sallust*,[m] in his new method. Owing, however, either to some defect in the plan, or to the want of skill in the execution of his specimen, Mr. GED's invention seems to have attracted but little notice. In 1782 Mr. ALEXANDER TILLOCH, of Great-Britain, revived, or rather re-discovered this art; for he is said to have been ignorant of GED's contrivance till long after he had announced his own. The subsequent year he took out a patent for it, in conjunction with Mr. ANDREW FOULIS, printer to the University of Glas-

k DARWIN's *Botanic Garden*, part i. canto 1, note.

l This word, which M. DIDOT of France, seems to have first employed, is derived from the Greek words, στερεος, *solidus*, and τυπος *typus*, denoting that the types are soldered, or otherwise connected together.

m In the title page of this edition there are the following words, viz. *Edinburghi: Gulielmus Ged, aurifaber Edinensis, non typis mobilibus, ut vulgo fieri solet; sed tabellis seu laminis fusis, excudebat.*

gow. About the year 1789 M. Didot, of France, seems to have invented, a third time, this valuable art, and to have contrived several important improvements, which render his mode much more convenient and useful than that of any of his predecessors." The *Stereotype* plan of printing is most happily calculated to secure accuracy in numerical tables, and in books of a similar kind. Indeed, for publishing all works of classical character, extensive sale, and permanent demand, it is an invaluable acquisition. The beautiful editions of several Greek and Roman classics, which have been executed in this manner, by the French artist above mentioned, are well known to be favourable specimens of this far-famed improvement.

In a considerable degree resembling the *Stereotype*, is the *Logographic* mode of printing, an invention announced in 1783, by Mr. H. Johnson, of Great-Britain. In this invention the types for printing, instead of answering to *single letters*, are made to correspond to *whole words;* a circumstance which points out the etymology of the name. The advantages of this new mode are said to be these: That the compositor has less charged upon his memory than in the common way; that he is much less liable to error; that he saves time, inasmuch as the type of each word is as easily and as readily set as that of a single letter; that the distribution afterwards is more simple, easy and expeditious; and that no extraordinary ex-

n The *Stereotype* mode of printing adopted by Didot is as follows. The page is first set up in moveable types; a mould or impression is then taken off the page with any suitable plastic material; and afterwards as many solid pages are cast from the mould as may be wanted. The plan adopted by Ged and others seems to have been different. After setting up the page with moveable types, they soldered them together, and thus formed a permanent page, from which as many copies might be stricken as were desired. The comparative merits of these different plans will readily present themselves to the intelligent reader.

pense, nor greater number of types is required in this than in the common mode of printing.[o]

Another improvement in the art of printing, which belongs to the last age, is the kind of impression called *Fac-simile*, or forming the types in such a manner as precisely to resemble the manuscript intended to be copied. The first approach to this method of printing was the Medicean Virgil, printed at Florence, in 1741. This, however, though an approximation to the plan, was by no means, strictly speaking, what is now meant by *fac-simile* printing, as the resemblance of the manuscript was not complete. The first great work of this kind was the New Testament, of the Alexandrian MS. in the British Museum, published by Dr. WOIDE, in 1786, which exhibits its prototype to a degree of similarity scarcely credible. Since that time, a few other works, of considerable extent, have been published on the same plan, particularly Dr. KIPLING's edition of the four Gospels and the Acts of the Apostles, according to the MS. of BEZA. But, for the most part, the practice in question has been confined to manuscripts of small extent, and to objects of especial curiosity.[p]

The art of forming *types*, for printing, has also received considerable improvements in the course of the eighteenth century. Among the numerous authors of these, the celebrated JOHN BASKERVILLE, an English artist, deserves particular notice. The diligence, zeal, and success with which he applied himself to improve the mode of founding types, and to give them a more beautiful form, are well known; as well as the numerous editions which he was enabled to give of important works, particularly the Latin classics, in a style of elegance far

o *Encyclopædia*, Art. *Logography*.
p *Monthly Review*, of London. vol. xii. N. S. p. 241.

surpassing every thing of the kind which had before issued from the press. Various inventions, to abridge labour in the business of letter-foundery, have also been made within this period; of these, perhaps, few are entitled to be mentioned with more respect than that of Mr. APOLLOS KINSLEY, an ingenious American, who is said to have devised a method of abbreviating, to an astonishing degree, the necessary process in this manufacture.[q]

The discoveries made within a few years past in the philosophy of *Tanning*, have greatly facilitated the process, and promoted the interests of that important art. For these the public are indebted to Dr. MACBRIDE, Messrs. FAY, SEGUIN, DESMOND, and several others.

The still more numerous and radical improvements which late years have produced in the art of *Brewing*, are no less worthy of notice. The successive investigations, and valuable writings of Sir ROBERT MURRAY, M. COMBRUNE, Mr. RICHARDSON, Mr. KER, and Mr. LONG, on this subject, are worthy of respectful notice in marking the progress of the age under review.

In the art of *Bleaching*, also, important discoveries and improvements were made, in the course of the last age, especially toward the close of it. The speculations and experiments of Drs. HOME and BLACK, and Mr. WATT, of Great-Britain; and of Messrs. CHAPTAL, BERTHOLLET, PAJOT DE CHARMES, and BEAUME, of France; besides those of many other chemists and practical artists, have contributed to place this art, so interesting to manufacturers, entirely on a new footing, within a few years past. Instead of the old process, which ordinarily employed a number of weeks, and even several months, recent discoveries have furnished

q *American Review, and Literary Journal*, vol. i. No. I.

means of reducing cloth to a state of beautiful whiteness in a few hours.

In the art of *Dyeing* no less signal progress has been made within a few years. The learned investigations and laborious experiments which have been successively instituted for the improvement of this art, by DUFAY, HELLOT, MACQUER, D'APLIGNY, and BERTHOLLET, of France; and by Messrs. DELAVAL and HENRY, and Dr. BANCROFT,[r] and others, of Great-Britain, are very honourably displayed in their respective works, and have been productive of great utility to several of the manufacturing classes of the community.

In the eighteenth century the first *Porcelain ware* ever manufactured in Europe was produced. The account of the invention is curious. JOHN FREDERICK BOTTGER, a German, about the year 1706, believed, or pretended, that he had learned the art of transmuting various substances into gold, from a goldsmith at Berlin. He went into Saxony, and was allowed all the requisite materials, and every assistance necessary for prosecuting his operations, by certain persons who thought proper to encourage him. For several years he laboured in vain. At last, imputing his want of success to the crucibles not being of a proper quality, he attempted to make these vessels himself, of a hard and durable kind; and in this attempt he accidentally produced porcelain.[s] The manufacture of this article was afterwards extended to France, Italy, and Great-Britain. But of all the countries of Europe, France produces porcelain in the greatest quantity, and of the best quality.

For many of the improvements lately made in several of the manufactures last mentioned, we are

r *Experimental Researches concerning the Philosophy of Permanent Colours*, by E. BANCROFT, M. D. &c. 1794.

s *Monthly Review*, vol. vi. N, S. p. 545.

much indebted to modern *Chemistry*. The important aid furnished to these, and a multitude of other mechanical operations, by the facts and principles brought to light in the course of recent chemical inquiries, is too well known to require explanation.

The manufacture of *Metallic Wares*, in modern times, has made astonishing progress, both in extent and refinement. In Great-Britain especially, those branches of the mechanic arts which belong to metallic substances, and particularly the manufactures of *Iron*, have received the greatest degree of improvement. The workmen, of that country, in this department of art, have been enabled, within a few years past, by various inventions and discoveries, to unite rapidity of execution, elegance of form and polish, excellence of quality, and cheapness of price, in their manufactures, to a degree without example in the history of human ingenuity.

But to recite the mechanical inventions and improvements which belong to the period under review would be a task almost without limits. To this class belong the ingenious experiments and valuable discoveries by Mr. WEDGEWOOD, in the art of *Pottery*, and in various kinds of manufactures in *Clay*; the invention of a new and more durable kind of + *Stucco* than had ever been used before, by Mr. HIGGINS; the numerous improvements which have been made in the composition and manufacture of *Glass*; the almost countless new plans for improving the construction of *Lamps*, by ARGAND and others; the various modes proposed for rendering *Stoves* and *Fire-places* more economical and comfortable, by FRANKLIN, RITTENHOUSE, RUMFORD, and PEALE; the new degrees of perfection to which *Clocks* and other

+ I think the ... discovery ... the use

Chronometers have been carried;[t] the invention of new vegetable materials for the formation of *Paper*, more plentiful, and easy of access than those of which alone it had been before made;[v] the method of *renovating old paper*, by a chemical process, cleansing it from all foreign matter, discharging the ink, and rendering it again fit to receive new impressions; the methods which have been devised for *multiplying copies* of prints and manuscripts, with ease, expedition, and cheapness; the various plans for *cutting Nails*, instead of the old and tedious method of forming them on the anvil, besides a multitude of others, scarcely, if at all less important, which time would fail to enumerate.

Finally, the effects of the various improvements which have been introduced into every department of the mechanic arts, during the last age, in promoting the conveniency, cheapness, and elegance of *living*, will readily occur to the most careless observer. No one will say that it indicates undue partiality to our own times to assert, that at no period of the world was the *art of living*, especially the comforts and conveniences of domestic life, ever on so advantageous a footing as at present. Ancient writers, indeed, have given highly co-

t Among the several improvers of *Time-keepers*, during the last age, HARRISON, ARNOLD, and KENDALL were before mentioned as deserving particular praise. The first named was bred a carpenter, and began by making wooden clocks. It is unnecessary to add, that, by the force of his genius he rose to the highest eminence as an artist.

v There is a particular reference here to the discovery of the Rev. Mr. SENGER, of Germany, that a certain aquatic plant, called by LINNÆUS *Conferva Rivularis*, is capable of being manufactured into paper, of as excellent a quality as that made of rags, and at less expense. The same discovery was made a short time afterwards by ROBERT R. LIVINGSTON, Esq. late Chancellor of the State of New-York, and now Minister Plenipotentiary to the French Republic, without any knowledge of what Mr. SENGER had done; and indeed some time before the German discovery had been communicated to the public. It has been also ascertained that paper of an excellent quality may be made of common *Straw*, and that, in a state of mixture with other materials, even *Saw-dust* is useful in fabricating the same substance.

loured pictures of the magnificence and sensuality which reigned at different times, in *Greece* and *Rome;* and in more modern days we read many descriptions of luxury which superficial thinkers would suppose to indicate much greater plenty, comfort, and splendour, than are now commonly enjoyed. But they are, for the most part, descriptions of plenty without taste, and of luxury without enjoyment. When we compare the ancient modes of living, with the dress,[u] the furniture, the equipage, the conveniences of travelling, and the incomparably greater ease with which the same amount of comfortable accommodation may be obtained at present, none can hesitate to give a decided preference, in all these respects, to modern times. Perhaps it would not be extravagant to say that many of the higher orders of mechanics and day labourers now wear better clothes, and live, not more plentifully, but in some respects more conveniently, more neatly, and with more true taste, than many princes and kings were in the habit of doing two centuries ago, and in a manner quite as pleasant as multitudes of a rank far superior to themselves, at a later period. In short, the remarkable and unprecedented union of neatness and simplicity, cheapness and elegance, which has been exhibited, in the art of living, within the last thirty or forty years, is, at once, a testimony of the rapid improvement of the mechanic arts, and one of the most unquestionable points in which we may claim a superiority over our predecessors.

u When the author speaks of the superiority of modern *dress* to the ancient, he wishes to be understood not as asserting that it is superior in its *form:* this he is persuaded would not be in all respects true: the full and flowing garments of the Greeks were, probably, more healthful, as well as more graceful; but in the *texture*, *conveniency*, and *cheapness* of dress, it is presumed later fashions have greatly the advantage.

CHAPTER X.

FINE ARTS.

ON the state of the fine arts, during the eighteenth century, it is not easy to speak in general terms. Were any remark of this kind to be made, it ought probably to be, that in this department of genius, the last age fell considerably below some preceding centuries. In all the branches of art, indeed, which come under this denomination, the period which we are considering had its luminaries; but they were only in a few instances of the first magnitude. For this comparative deficiency some at least plausible reasons may be assigned.

It has been said that, though an art, in its progress toward perfection, is greatly promoted by emulation, yet, after arriving at maturity, its decline is no less hastened by the same spirit. On this principle it has been supposed that the great works of the ancient masters, presenting to modern artists so high a degree of excellence, either discouraged all competition, or prompted those who would not submit to be humble imitators, to attempt something new, which, in most cases, proved to be degeneracy rather than improvement.

Much greater pains have been taken, during the last age, to form many, by laborious instruction, to practise the fine arts, than to encourage and honour those who possessed native genius. Hence the number of smatterers in the arts, during this period, has risen to an unprecedented amount. These have all subtracted more or less of the patronage which would otherwise have been

directed to the most deserving; and thus, by obvious means, robbed the latter of no small share both of fame and excellence.

But if the eighteenth century were less distinguished than some preceding ages, for *producing* specimens of first-rate excellence in the fine arts, it may safely be pronounced to exceed all other periods in forming numerous, large, and splendid *collections* of specimens of this kind. The monuments of human genius, especially in painting and sculpture, collected and displayed in the city of Paris, at the close of the century, are undoubtedly more numerous and magnificent than were ever before exhibited in one place.[w] Next to these the collections of a similar kind in Germany, Petersburgh, and Great-Britain, are entitled to high distinction for their extent and excellence.

In several of the departments of the fine arts there are a few names and improvements which distinguish the eighteenth century, and which deserve to be noticed in this retrospect.[x]

PAINTING.

In this noble art the century under consideration is honourably distinguished. From the fifteenth century till toward the middle of the eighteenth, scarcely any painters of first-rate excellence had appeared. The mantles of those great

w The violation committed on the treasures of the fine arts in Italy, in the course of the late war, under the sanction of the French government, while it certainly cannot be justified on the principles of national probity and honour, may, perhaps, have an unfavourable influence on the progress of the arts in France.

x Several of the facts and names mentioned in this chapter were communicated to the author by Mr. John R. Murray, of the city of New-York, a young gentleman of extensive information, and excellent taste in the fine arts, who has just returned to his native country, after making the tour of Europe, where he viewed the noble collections which that part of the world affords, with a degree of intelligence and accuracy of observation by no means common among travellers.

masters, MICHAEL ANGELO, RAPHAEL, and other contemporary artists, seem not to have fallen upon any of their successors. At the commencement of the century KNELLER, DAHL, RICHARDSON, JERVAS, and THORNHILL, of Great-Britain, were conspicuous in their respective departments of painting; as were also CIGNANI, GIORDANO, MARATTI, JAUVENET, and many others on the continent of Europe. But these artists, though unquestionably of the first class then known, were inferior, particularly the former group, to many who had gone before them, and by no means equal to some of their successors.

Though the eighteenth century produced fewer painters of great and original genius than several preceding ages; yet it is remarkable for having produced an unprecedented number, who, with a moderate portion of genius, and with great industry, have risen to high respectability in this art. There was, no doubt, more painting performed by artists of this period, than during any former one of similar extent since the art was cultivated. The most numerous, and the most excellent painters, during the century in question, have been produced in Italy, Great-Britain, France, and the United States.

The painters of Great-Britain, about the year 1750, with the view of promoting their art, associated together, and formed a kind of academy, which was supported by annual subscription. This association was continued, with various changes in the degree of its respectability and success, until 1768, when the *Royal Academy of Painting, Sculpture, and Architecture* was established, under the auspices of the British King, and composed of the ablest artists residing in that country. In the establishment of this institution no individual was more active, or exerted a more useful influence, than Sir JOSHUA REYNOLDS, who held the highest

rank in his profession, and who was, for many years, President of the Academy. From the rise of this institution, which at once furnished a *School* for instruction, a scene of *Annual Exhibition*, and numerous excitements to emulation, we may date the revival of a correct taste for the fine arts in Great-Britain.

In the last twenty years of the century, many specimens of painting were produced by British artists, which give them high distinction in a comparative estimate of their talents with those of other nations. Towards producing this effect much has been ascribed to the eloquent and instructive discourses of Sir JOSHUA REYNOLDS, who appears to have taken unwearied and successful pains to form the taste of his pupils on the principles of the great masters of the Italian and Flemish schools. His exertions to promote a just taste in this art have been very honourably seconded by those of WEST,[y] FUSELI, and others who hold a distinguished place in the British school of arts.

The *Historical Painters* of the eighteenth century were numerous, and some of them highly respectable. Among these CIGNANI, GIORDANO, MARATTI, and JAUVENET, before mentioned, held, early in the century, an honourable rank. At later periods, the Italian school has been adorned by BATTONI, MENGS, MARTINI, DIETRICH, and several others. In Great-Britain the works of WEST,

y Mr. BENJAMIN WEST (now Sir BENJAMIN) is a native of Pennsylvania. About the year 1763 he went to Italy, under the patronage of WILLIAM ALLEN, Esq. Chief Justice of the then province, whose son accompanied him. After studying the monuments of ancient and modern genius in Italy, he went to Great-Britain, where he has since resided, and where the productions of his pencil have been rewarded with distinguished honours and emolument. The works of this artist are too numerous to be mentioned. His suite of *sacred* paintings for the Royal Chapel at Windsor have been much celebrated. Besides these, his *Death of Wolfe*, his *Battle of La Hogue*, his *Battle of the Boyne*, and his *Flood*, are considered as deserving particular distinction. He is said, by some good judges, to be, on the whole, the greatest painter in his department now living.

REYNOLDS, COPELY,[z] and TRUMBULL,[a] have been much celebrated. In France the national taste had been for some time perverted by the influence of BOUCHER. But in the latter half of the century a better taste was formed in that country by the genius and exertions of DAVID, GUERRIN, VINCENT, REGNAULT, GERRARD, and GIRODET, whose productions hold a high place in the estimation of modern connoisseurs.

The eighteenth century is distinguished above all preceding ages by the remarkable prevalence of a taste for *Comic Painting*. The great original in this branch of the art was WILLIAM HOGARTH, an English artist, whose genius and works have been long and universally famed. This wonderful character is, perhaps, to be viewed rather as a writer of comedy with a pencil, than as a painter. He invented a new species of dramatic painting, in which all the ridicule of life became concentrated and embodied by his magic touch, to a degree altogether unknown in any former artist, and in which he will probably hereafter have few equals. His talent for depicting the comic is thus described by one of his cotemporaries. "If catching the manners and follies of an age ' living as they rise,'

z Mr. JOHN SINGLETON COPELY is a native of the State of Massachusetts. He went, a few years ago, to Great-Britain, where he was patronized and instructed by Mr. WEST, and where he has been since very honourably distinguished as an artist. His *Death of Chatham*, and his *Siege of Gibraltar*, are generally considered among the most respectable monuments of his genius.

a Mr. JOHN TRUMBULL is a native of the State of Connecticut. His father was Governor of that State for a number of years, and was much distinguished for his talents and patriotism. His Excellency JONATHAN TRUMBULL, the present Governor of Connecticut, is his brother. This gentleman early discovered a great fondness for the art, in which he has since made such honourable proficiency. He studied for some time under the direction of his illustrious countryman, Mr. WEST, who is not more distinguished by his abilities as an artist, than by his exertions in bringing forward American genius. Mr. TRUMBULL has presented the public with several historical paintings, which place him high among the artists of the eighteenth century. His best pieces are the *Death of Montgomery*, the *Battle of Bunker's Hill*, and the *Sortie of Gibraltar*.

if general satire on vices and ridicules, familiarized by strokes of nature, and heightened by wit, and the whole animated by proper and just expressions of the passions, be comedy, HOGARTH composed comedies as much as MOLIERE. He is more true to character than CONGREVE; each personage is distinct from the rest, acts in his sphere, and cannot be confounded with any other of the *dramatis personæ*. HOGARTH had no model to follow and improve upon. He created his art, and used colours instead of language. He resembles BUTLER; but his subjects are more universal; and amidst all his pleasantry, he observes the true end of comedy, reformation. There is always a moral to his pictures."[b] It is remarkable, however, and deserves to be mentioned as an instructive fact, that while his mind was so richly stored with materials for exhibiting the common scenes of life; while he possessed such unrivalled powers in displaying the ridiculous, he could not rise to the great historical style of painting, and whenever he attempted it egregiously failed.[c]

It is worthy of remark, that, since the time of HOGARTH, a taste for *Caricatura*, and for comic painting in general, has evidently increased, especially in Great-Britain, to a degree beyond all former example. Notwithstanding the phlegmatic character usually ascribed to the British, it is a curious fact, that, in no country on earth has the taste for this species of painting been so fashionable, or carried to so high a degree of perfection. In a particular department of comic painting, Mr. HENRY BUNBURY has much distinguished himself. His exhibitions of scenes in *Tristram Shandy*, and other works, present his

b Lord ORFORD's (HORACE WALPOLE's) *Works*, vol. iii. p. 453, &c.
c Sir JOSHUA REYNOLD's *Works*, vol. ii. p. 163.

genius in very strong and lively colours, and deserve to be mentioned among the signal peculiarities of the age. BUNBURY is the only successful imitator of HOGARTH, and is among the very few imitators who rise, in their respective kinds of excellence, to full equality with their original. Like his great predecessor, he displays more humour when he invents than when he illustrates.

It is probable that *Portrait Painting* was never before so much practised as in the eighteenth century.[d] In this branch of the art Sir JOSHUA REYNOLDS was the great and unrivalled master. "This celebrated painter," says an eloquent writer, "was the first Englishman who added the praise of the elegant arts to the other glories of his country. In taste, in grace, in facility, in happy invention, and in the richness and harmony of colouring, he was equal to the great masters of the most renowned ages. In *Portrait* he went beyond them, for he communicated to that description of the art, in which English artists are the most engaged, a variety, a fancy, and a dignity, derived from the higher branches, which even those who professed them in a superior manner did not always preserve when they delineated individual nature. His portraits remind the spectator of the invention of history, and the amenity of landscape."[e]

But Sir JOSHUA REYNOLDS was not alone in this department of painting. Many others, though not all equally deserving, are entitled to a place among those distinguished artists who do honour

d A taste for *Portrait Painting* has perhaps been more prevalent in Great-Britain, especially during the last age, than in any other country on earth; insomuch that some foreigners have brought the charge of vanity against the English on this account. But a more serious consideration is, that this taste, by limiting the cultivation of historical subjects, has had a disadvantageous influence on the higher branches of the art.

e Character by BURKE, in the life of Sir JOSHUA REYNOLDS by MALONE, 8vo. p. 119.

to the period under review. Besides a number of others who might be mentioned, the merits of LAWRENCE, RAMSAY, GAINSBOROUGH, NORTHCOTE, OPIE, BEECHEY and BARRY, of Great-Britain; of GREUZE, of FRANCE; and of STUART,[f] of the United States, entitle them to the highest praise.

That mode of delineating the human countenance called *Miniature* painting, though practised prior to the age under consideration, yet may be said to have gained a prevalence, and attained a degree of excellence, during that age, which were altogether unknown in any former period.

In *Allegorical* painting, ANGELICA KAUFFMAN, a distinguished genius of Germany, now residing at Rome, was perhaps never exceeded. In that vigorous imagination which enables an artist, as it were, to embody and depict metaphysical ideas, Mr. FUSELI has displayed unrivalled talents. In *Landscape*, GAINSBOROUGH, WILSON, SMITH, TURNER, and several others, have attained high distinction in Great-Britain; as have also VERNET and VALENCIENS, of France; OMMAGANK, of Antwerp, and several others in different parts of Europe. In depicting *Cattle*, and various kinds of

[f] Mr. GILBERT STUART, the celebrated portrait painter, is a native of the State of Rhode-Island. He discovered, early in life, a taste for painting. This was encouraged by a friend of the family, who had himself considerable skill in the same art, and who took young STUART with him to Great-Britain, where he spent several years before he reached the age of manhood. On returning to his native country, and discovering a growing fondness for the pencil, he was patronized by Mr. JOSEPH ANTHONY, a respectable merchant of Rhode-Island, afterwards of Philadelphia, by whom he was again sent to England, and placed under the tuition of Mr. WEST, where he made great proficiency, and soon became distinguished as a portrait painter. The high reputation which he has since gained in this branch of the art, is generally known, both in Great-Britain and America. A late satirical, and in many respects, very exceptionable writer, speaking of this gentleman, expresses himself in the following terms: "I do not know any living artist to whom I would so eagerly sit, for an immediate and faithful resemblance, as to G. STUART, as, I believe, he sees his object, and the infinity of tints constituting that object, with more perspicuity than any other existing portrait painter." See ANTHONY PASQUIN's *Royal Academicians*.

Animals, VERNIX and OMMAGANK, of the Flemish school; and STUBBS, GILPIN, and CATTON, of Great-Britain, may be honourably compared with the painters of any age. VAN HUYSUM, of Amsterdam, may be considered the greatest painter of *Flowers* that ever lived; and in the same class VAN SPANDONCK, of the French school, is entitled to respectful notice.

The century under review is distinguished by the recovery of the *Encaustic* method of painting, which was much used by the ancients, but had been long lost. This method consists in the use of *wax* to give a gloss to colours, and to preserve them from the injuries of the air. The restoration of this art is ascribed to Count CAYLUS, a member of the *Academy of Inscriptions* in France, and was announced to the Academy of Painting and Belles Lettres in 1753; though M. BACHELIER had actually painted a picture in wax in 1749; and he was the first who communicated to the public the method of performing the operation of *inustion*, which is the principal characteristic of the encaustic painting. Some additional facts were afterwards brought to light, and some improvements in this art were proposed, by Mr. MUNTZ, in an elaborate treatise on this subject. A different and improved species of encaustic painting was next discovered, in 1759, by Mr. JOSIAH COLEBROOK, of Great-Britain; and, finally, Miss GREENLAND, of the same country, in 1787, communicated to the society of arts, some further discoveries and improvements, which were rewarded by that association with a prize. This method of painting has many advantages. The colours laid on in this manner have all the strength of painting in oil, and all the airiness of water-colours, without partaking of the defects of either. They are firm, will bear washing, and may be retouched at plea-

sure, without injury. The duration of this kind of painting is also an advantage; the colours are not liable to fade and change; no damp, or corrosive substance can affect them; they have no tendency to crack; and if by accident they receive injury, they can be easily repaired.[g]

A new kind of painting, called the *Elydoric*, which name it derives from *oil* and *water* being both used in its execution, was invented a few years ago by M. VINCENT, of France. The great advantages of this invention are, that, by means of it the artist is enabled to give a very high finishing to small figures in oil, and to add to the mellowness of oil-painting, the greatest beauty of water-colours in miniature; and to do this in such a manner that it appears like a large picture seen through a diminishing glass.[h]

The art of *Painting on Glass* was revived in Great-Britain during the eighteenth century, and brought, by the artists of that country, to as great, if not greater, perfection than it had ever before attained. In effecting this revival, the celebrated JERVAS, a British painter, was, among others, much distinguished.

The invention of a more perfect manner of preparing *Water-Colours*, about the year 1778, by Mr. THOMAS REEVES, of Great-Britain, also deserves to be mentioned as an important event in the history of modern painting. The numerous advantages conferred on the art of drawing in water-colours, by this invention, are generally known, and can scarcely be too highly appreciated.

In the year 1787 was announced the invention of what is called *Polygraphic Painting*, by which paintings in oil may be multiplied, by a chemical

g See Encyclopædia, art. *Encaustic Painting.*
h *Ibid.* art. *Painting.*

and mechanical operation, to a wonderful extent. The numerous copies obtained, by means of this invention, are said to possess great excellence. The utility of this art, if its merits be such as have been mentioned, is too obvious to require explanation.

A method was invented not long since by Mr. ROBERT SALMON, of Bedfordshire, in England, of transferring valuable paintings from the substance on which they were originally painted, to another and more eligible one. The utility and importance of this invention will be readily appreciated by every intelligent reader.

Numerous experiments have also been made, during the last age, with respect to the best mode of preparing and laying on *Colours*. For these, the art of painting is indebted to several chemists and practical artists. But they are too numerous, and would require too much minuteness of detail to be explained in the present sketch.[i]

Finally, to this section belongs some notice of the art of *imitating pictures in Needle-work*, which has been brought to greater perfection during the eighteenth century than ever before. In very early times we read of specimens of *needle-work*, by the hands of celebrated females, which attracted much attention, and which were exhibited as decorations of dwellings, and as monuments of ingenious industry. But within a few years past, improvements have been made in this elegant art, which far surpass the most renowned productions of the same kind in former ages. The

[i] The laborious and ingenious experiments made by modern artists, particularly those directed towards the recovery of the celebrated *Venetian* mode of colouring, have not been attended with so much success as might have been expected. Mr. WEST has been much engaged in this inquiry, but without, as yet, attaining the desired object. His colours, however, are good and permanent. The same cannot be said in favour of Sir JOSHUA REYNOLDS. His colouring, though much praised in his day, is now found to fade exceedingly. *M. S. note of Mr.* J. R. MURRAY.

names of several ladies might be mentioned, who have much distinguished themselves by contributing to these improvements; but among these, the genius and works of Miss LINWOOD, of Great-Britain, hold an undisputed pre-eminence. The needle, in the hands of this lady, has become a "formidable rival of the pencil." The pieces she has wrought so far transcend, both in number and excellence, all preceding attempts, that they may, with great justice, be placed among the distinguishing honours of the period under review.

SCULPTURE.

In this art, the eighteenth century, though it has produced some respectable masters, yet falls far short of those renowned monuments which do so much honour to Grecian and Roman genius. Of that portion of skill in sculpture which has fallen to the lot of modern artists, the largest share, as in former periods, belongs to those of Italy. In that country CHERACCHI, COMOLLI, CARLINI, ALGARDI, and above all, CANOVA,[j] have been much distinguished. Besides these, ROUBILLIAC, LA MOITE, CHAUDET, HOUDON, and BOIZOT, of France; RYSBRACH and FIAMINGO, of Flanders; SCHADDAU, of Berlin; BACON, NOLLEKENS, WILTON, FLAXMAN, MOORE, BANKS, and the honourable Mrs. DAMER,[k] of Great-Britain; SERGEL, of Sweden; and a few others, in different parts of

j CANOVA resides at Rome. The author is informed, by Mr. MURRAY, that this artist is undoubtedly the greatest sculptor now living, and fully equal to the second class of Grecian sculptors. Mr. MURRAY, when at Rome, was often in the workshop of CANOVA, and declares, that, on comparing a statue of *Perseus*, executed by him, with a casting from the *Belvidere Apollo*, placed in the same room, the former suffered very little by the comparison.

k Mrs. DAMER is the first instance, in the annals of sculpture, of a *female* attaining distinction in this art. Some of her works do her great honour.

Europe, have attained, within the period in question, considerable celebrity.

The art of taking human likenesses in *Wax*, though not absolutely peculiar to the eighteenth century, has been carried to a degree of perfection during this period, which was never before known. In this art, Mrs. Wright, an ingenious American lady; Mr. Gossett, and his nephew, of Great-Britain; and several others on the continent of Europe, have gained very honourable distinction.

The various compositions for *Busts* and other kinds of statuary, which modern genius has invented, are worthy of notice in this brief sketch of the peculiarities of the last age. Those, in particular, by Wedgewood and Bentley, of Great-Britain, are entitled to the highest praise. Modern artists are also distinguished above all others by the facility and accuracy with which they take *copies* of antique specimens of sculpture in common plastic materials. The utility as well as elegance of this mode of multiplying the monuments of ancient genius make it worthy of being noticed among the honours of the eighteenth century.

In France a new method of representing the human figure has been lately adopted. Guirhard and Dehl, of that country, in 1800, completed a human figure in *Porcelain*, of four feet high. This is probably the largest made of the same material ever seen. They can, however, still magnify them to the size of life. The advantages to be derived from adopting this kind of statuary, are durability, cheapness, and expedition and ease of production. Porcelain is as hard as silex, and less liable to injury than marble. These figures may be prepared in a mould, by which means the statues of great men may be multiplied with little labour and at a small expense.[l]

[l] Garnett's *Annals of Philosophy*, &c. for 1800.

Mr. James Tassie, of London, with a view to the further advancement of the imitative arts, has discovered a method of transferring the figures and heads of antique and modern engraved gems into coloured glass and enamel, similar to the originals in colour, durability and brilliancy. This has been pronounced by some connoisseurs to be a discovery of great value for perpetuating the works of miniature sculpture. By means of it, many remains of ancient genius which were lost to the world, in general, may be universally diffused in all their original beauty and excellence."[m]

Towards the close of the century under consideration, a collection was made, in Paris, of all the *Monuments of Sculpture* which France could afford, from the eighth to the eighteenth century, and arranged according to the order of centuries. This is the first, and the only collection of the kind ever made. It is the only school in which the progress of sculpture during the middle ages can be advantageously studied."[n]

ENGRAVING.

This art, which was not known prior to the middle of the fifteenth century,[o] was brought, in the course of the eighteenth, to a degree of refinement and perfection which forms one of the signal honours of the age. And although some specimens of this art, of a very early date, display the spirit of the painting they were intended to copy, with

m Monthly Magazine, Lond. vol. vii.

n *Description Historique et Chronologique des Monumens de Sculpture, reunis au Musee des Monumens Français; par* Alexandre Lenoir.

o The ancients, it is true, practised engraving on precious stones and chrystals, with very good success; but this is rather a species of sculpture. The art of engraving on plates of metal, and blocks of wood, from which to take prints or impressions, was not known till the period above mentioned.

a success which has never been exceeded; yet, considering the general excellence of engraving, it certainly never attained so high a degree of improvement, in all respects, as during the century under consideration. The instruments for prosecuting this art have been, within the period in question, greatly improved both in power and convenience; new kinds of engraving have been invented; and the methods before known carried to an extent of beauty and elegance unknown to the artists of any preceding times.

A method of *Engraving on Glass* was invented toward the close of the century under consideration. This is done by means of the *Flour Acid*, discovered a few years ago by MARGRAAF and SCHEELE. To effect this kind of engraving a glass plate is covered with melted wax or mastic. When this coating becomes hard, it is engraved upon by a very sharp pointed needle, or other instrument of that kind. A mixture of oil of vitriol and *flour acid* is then put upon the plate, and the whole covered with an inverted china vessel, to prevent the evaporation of the acid. In two days, the plate being cleared of its coating, exhibits all the traces of the instrument.

Engraving in *Aquatinta* is also a recent invention. This is a method of *Etching* on copper, by which a soft and beautiful effect is produced, resembling a fine drawing in water-colours or Indian ink. The artists who most distinguished themselves in this department of engraving within the period under consideration, were SANDBY, PARKYNS, and JUKES, of Great-Britain.

Calcography, a species of engraving in imitation of *Chalk drawings*, if not invented, was first brought to a high state of excellence and improvement, in the eighteenth century. Those who have been most eminently distinguished in this depart-

ment of the graphic art, are Messrs. Ryland and Bartolozzi, of Great-Britain.[p]

Mr. Smith, an engraver of London, toward the close of the period embraced in this retrospect, is said to have invented a method of making impressions from his own plates, so to resemble *Oil Paintings* as to be with difficulty distinguished from them, even by connoisseurs. These impressions are represented as possessing that sort of brightness which is so much admired in Venetian paintings, as resembling them also in permanency, and as being of such a nature as to render a covering of glass, so expensive and frangible a material, altogether unnecessary.

The art of producing *Coloured Engravings* belongs almost entirely to the period under consideration. About the time of the revival of learning, some artists produced prints of different colours, by means of *Wood-cuts*, employing a different plate for each colour. But so much inconvenience and imperfection attended this method that it was seldom resorted to. No further improvement seems to have been attempted till near the middle of the eighteenth century, when some experiments were made by French artists, with *Copperplates*, with a view to obtain coloured prints. They also found it necessary to use different plates for different parts of the work; and on this, as well as other accounts, the expense of their plan prevented its general adoption. But toward the close of the century a method was invented of producing an elegant coloured engraving from a single copperplate. The English artists are said to have carried this improvement to the greatest degree of excellence.

p For this, and for several other articles of information, detailed in the present section, and for some valuable hints on the subject of modern painting, the author acknowledges himself to be indebted to Mr. Archibald Robertson, conductor of the *Columbian Academy of Painting* in the city of New-York, whose ingenuity and taste as an artist are well known.

A method of engraving is said to have been lately invented by Mr. WESTALL, an artist of London, more nearly resembling *Drawings* than was before known. In 1799 he exhibited a drawing, and the year following a print taken from it, which was so close an imitation as to deceive the eye.

The art of *Engraving on Wood* had been practised for several centuries before the eighteenth, but degenerated, and became little used. At the close of the seventeenth century it was in a very low state, and had almost sunk into forgetfulness, when THOMAS BEWICK, of Great-Britain, a few years ago, revived it. He is said by some, indeed, to be entitled to the honour of re-inventing the art; and has certainly brought it to a degree of elegance and perfection unknown to former artists. His pupils, NESBIT and ANDERSON, also of Great-Britain, have been for a considerable time distinguished by their taste and skill in this branch of engraving. To these names may be added that of Dr. ANDERSON, of New-York, who has much signalized himself by his genius for the same art.

A method has been, within a few years, devised of taking off an impression of any figures or writing drawn on the surface of *Marble*. The advantages of this invention are great ease and promptness of execution, and the facility of multiplying, to a great extent, the number of copies.

The eminent engravers of the eighteenth century were numerous. Among those who have either improved the art, or produced specimens very honourable to their characters, it will be proper to mention a few names. WOOLLETT,[q]

[q] WILLIAM WOOLLETT is said, by some, to have been the greatest engraver that ever lived. MORGAN has the character of being the most accomplished now living. His print of the *Last Supper* holds a very high place in the estimation of connoisseurs. BARTOLOZZI also stands near the head of the first class of living artists.

STRANGE, RYLAND, MORGAN, SHARPE, and HEATH, of Great-Britain, stand high in the list of modern engravers. AUDRAN, MONET, SIMON, and BEAUVARLET, of France, have received much praise; and PORPORERTI, MORCHAN, BARTOLOZZI, TESTOLINI, CYPRIANI, and several others, of Italy, deserve to be mentioned with the greatest respect.

MUSIC.

In the art of *Music*, the century under consideration furnished several events and characters worthy of being recorded. These relate either to discoveries and improvements in the principles of music; distinguished composers in this art; or those who have rendered themselves famous by the excellence of their personal performances.

The principles of music have been considerably improved during the last age. The origin and laws of *Harmony* were little understood before the commencement of this period. Facts and rules were known; and the improvements of the celebrated CORELLI, in *Counterpoint*, at the close of the preceding age, have received great and just praise. But the philosophy of harmony had been very imperfectly developed until M. RAMEAU, a scientific musician of France, early in the century, undertook the investigation of this subject, and introduced into it more light and order than had been before known. He exhibited the foundation and the principles of harmony, and the source of that pleasure which it affords; he analysed the consonances in music; he explained the mutual dependence of harmony and melody, and formed the laws of each into a distinct code, in a manner more luminous and satisfactory than any of his predeces-

sors.[r] The result of his labours was given to the world in 1752, when he was considered by many as the great monarch of the musical world, as "a theorist to whom this art was as much indebted as physics and philosophy to NEWTON." And although this opinion of his merit, entertained by his countrymen, may be more honourable than he deserves, yet the science of music is doubtless indebted to him as one of its greatest cultivators and improvers, during the age in which he lived.[s] The system of RAMEAU has received successive illustrations and improvements from M. D'ALEMBERT; Abbé ROUSSIER, and others.

Another great theorist in music was TARTINI, an ingenious Italian, who followed M. RAMEAU; and although the scientific correctness of his work is called in question, it still abounds with most valuable instruction to practical musicians. To these may be added the large and enlightened works of MARPURG, a great German musician; besides the publications made in different parts of the world, on particular departments of music, of which even the principal are too numerous to be recounted.[t]

This new light shed on the principles of music, has enabled succeeding artists to carry what is called *Modern Symphony*, which took its rise long before, to a very high degree of refinement and perfection. Those who have been most distinguished in this department are VANHALL, HAYDN, PLEYEL, and MOZART, all of Germany, and composers of the first class. In the new style of music introduced by these artists greater attention than formerly is paid to *contrast* and *effect*; and it is also distinguished by more *sprightliness* and *variety*.

r See D'ALEMBERT's *Elemens de Mus. Theor. et Prat. suivans les Principes de* RAMEAU, 1762.

s BURNEY's *History of Music*, 4to. vol. iv. p. 612, &c.

t *Ibid.*

And if it be less simple, less easy of acquisition, and, in some instances, less harmonious than that of their immediate predecessors, it contains, at the same time, a greater predominance of *air* and *melody*, and is better calculated to make impressions new, surprising and diversified.

It was about the beginning of the century under consideration, that Italian music first became fashionable in England. The first *Opera*, upon the Italian plan, was performed in that country in 1705. Compositions derived from the same source, have since become more popular and general. How much this kind of musical drama, invented by POLITIAN, is indebted to METASTASIO for its improvement, is generally known.

The sacred musical drama, or *Oratorio*, was invented in Italy in the beginning of the fourteenth century; but was never publicly exhibited in Great-Britain until introduced by GEORGE FREDERICK HANDEL, in 1732. This wonderful genius had come from Germany to England about twenty years before, and by his zeal, and the incomparable excellence of his compositions, formed a grand era in the history of music. Perhaps no individual musician of the age has been more frequently the subject of eulogy, or filled a larger space in the public estimation than this illustrious German. His *Oratorios*, including the *Chorusses*, which he brought into use, were exhibitions of the very first order.[v]

It would be improper to omit taking notice in this place of a new musical instrument, which the century we are considering produced, denominated by Dr. FRANKLIN the *Harmonica*. This is an instrument formed of glass, on which, by rubbing the finger according to certain rules, the most de-

v BURNEY's *History of Music*, vol. iv.

lightful music is produced. Mr. PUCKERIDGE, an Irish gentleman, about the middle of the century, was the first who contrived to play regular tunes on an instrument of this kind. After his death, Mr. DELAVAL, an ingenious member of the Royal Society in Great-Britain, made a musical instrument on the same principles, but with a better choice and form of glasses. In this stage of the invention, Dr. FRANKLIN undertook to investigate the subject, and considerably improved upon Mr. DELAVAL's plan, giving it the name which has been mentioned.[u] Since Dr. FRANKLIN, Dr. E. CULLEN, of Dublin, has formed an instrument of the same nature, but much more extensive and complicated, which he thinks so different as to require a new name. The great excellences of the *Harmonica*, as an instrument of music, are, that "its tones are incomparably sweet, beyond those of any other; that they may be swelled and softened at pleasure, by stronger or weaker pressures of the finger; that they may be continued to any length; and that the instrument being once well tuned, never again wants tuning."

The century under consideration has also produced a new species of musical instrument, called the *Euphon*, invented in 1790, by Dr. CHLADNI, a philosopher of Germany. Like the *Harmonica*, it is performed with the hand, on *glasses;* but it differs from that instrument in several respects. The music of the *Harmonica* is produced by rubbing the edges of glass vessels, in a circular direction; whereas the music of the *Euphon* is effected by rubbing the surface of long glass tubes, in the direction of right lines. In the number and sweetness of its tones, the latter approaches nearly to the excellence of the former; but is much superior in

[u] See FRANKLIN's *Letter to Father Beccaria*, on this subject.

simplicity; in the ease and expedition with which the music is produced; in cheapness of construction; and in having so little disagreeable effect on the nerves of the performer.[w]

A new species of *Hunting Music* was invented in *Russia*, a few years ago, by J. A. Maresch, master of the Imperial chapel, who died in 1794. It is performed entirely on *Horns*, of different sizes and figures, some long and strait, others short and curved, but all of the same tone. These instruments are said to be carried to such perfection, that the *Quartettos* and *Quintettos* of Haydn, Mozart, and Pleyel may be performed upon them, and the *Concertos* of Giarnovichi executed, even to the *Shake*, with admirable precision and ease.

The great musical *Composers* of the eighteenth century were very numerous. It will be possible to take notice only of a very small number among the most distinguished. Of these there were in England, Arne, Greene, Boyce, Avison, Arnold, and Burney; in France, Rameau, Bertier, Piccini, Gosec, and Gretry; in Germany, besides the illustrious names before mentioned, Graun, Abel, Fischer, Bach, Gluck, Fuchs, Fasch, Richter, and Stamitz; and in Italy, Martini, Jomelli, Metastasio, Bononcini, Raimonde, Salamon, Alessandri, and many others.

The great musical *Performers* of the eighteenth century were probably more numerous than those of any preceding age. Of these by far the greater number were natives of Italy and Germany, especially the former. They were so many, indeed, that no attempt will be made in this place to give a list even of the most conspicuous. Nor is such an enumeration necessary. The fame of the as-

w Tilloch's *Philosophical Magazine*.

tonishing musical powers possessed by NICOLINI, FARINELLI, GABRIELLI, CARESTINI, GIARDINI, RUBINELLI, MARCHESI, and a multitude of others, has long pervaded the civilized world.

The year 1784 was rendered a memorable era in the annals of music, by the splendid and magnificent manner in which the birth and genius of HANDEL were celebrated in Westminster Abbey, and the Pantheon, under the immediate auspices of the King and Queen of Great-Britain, and the other most dignified personages in the kingdom. This commemoration has been since established as an annual musical festival, for charitable purposes.[x] The number and excellence of the performers engaged in this commemoration, and the style of the music exhibited by them, may be safely pronounced to have exceeded every thing of the kind of which the history of the art gives us any account.[y]

ARCHITECTURE.

In this art the last century presents little which, by the attentive inquirer, can be considered as remarkable. Many noble specimens of architecture have been produced during this period, but probably few if any of these are equal to some of the productions of former times. There appear to be two circumstances in the architectural history of the eighteenth century, in which it differs from that of preceding ages.

The first is, that the *Public* buildings erected during this period will be found, in general, less grand and massy than those of some former periods.

x *Encyclopædia Britannica*, art. *Music.*

y In 1784 this commemoration was celebrated by 500 voices and instruments; in 1785, by 616; in 1786, by 741; in 1787, by 806. These performers were, in general, of the very first class, collected from every part of Europe.

But while they fall short in splendour and magnificence, they are probably much superior to most of the ancient specimens of architecture in simplicity, convenience, neatness, and real elegance. This difference probably arises, in some degree, from the well known fact, that most of the monuments of ancient taste and skill in architecture belong to countries and times when despotic sovereigns were able to command the property and the labour of millions, and when building cities and temples was one of the standing habits, and chief honours of great potentates. Since the revival of the arts these circumstances have so seldom met together, and particularly in those countries which have been most capable of profiting by them, that buildings on a plan of great splendour and magnificence have been undertaken comparatively seldom. But convenience, neatness, and simple elegance, as they are within the power of taste in all nations and ages, have been displayed, it is believed, with peculiar frequency in the last century.

The other peculiarity in the architecture of the last age is, that *Private Dwellings*, during this period, became, in general, more spacious, convenient, and agreeable to a correct taste, than ever before. In all preceding ages, even those which were most favourable to the arts, the number of large and convenient private houses was small. While public buildings were studiously extended and ornamented, only a few of the most wealthy possessed large, comfortable, and beautiful habitations. The number of this description has greatly increased in modern times. The manifest augmentation, in the course of the last century, of that respectable and useful portion of society usually called the *Middle Class*, has, no doubt, led to this improvement. It may probably be asserted that a

larger proportion of mankind were, at the close of the century under review, furnished with convenient, and even elegant habitations, than ever before enjoyed the like advantage.

The liberal use of *Glass*, in modern buildings, greatly contributes to their beauty and comfort, and is a point in which they peculiarly excel. And in descending to the various minute details of human dwellings, especially those which relate to elegance and enjoyment, it is evident, that in many respects the artists of the eighteenth century exceeded all others.

Our own country, during the period under consideration, has furnished but few objects worthy of being contemplated or recorded. Pursuits of more immediate utility and profit have generally occupied the attention of our citizens, and must continue to occupy it, until their wealth and taste shall be greatly augmented. That America is not deficient in native genius for the fine arts, the names of WEST, COPLEY, TRUMBULL, and STUART, before mentioned, abundantly testify; and that it can boast of many artists who want nothing but instruction, and incitements to exertion, to place them in a very honourable rank, experience daily renders more probable.[z] A taste for the fine arts in our country is evidently on the increase.[a]

z Among many names which might be mentioned to justify this remark, it would, perhaps, be improper to omit taking notice of Mr. VANDERLYN, a native of Ulster county, in the State of New-York. This young gentleman very early in life discovered a taste for painting. For the purpose of encouraging and cultivating this taste, he was sent to Europe, a few years ago, under the patronage of AARON BURR, Esq. now Vice-President of the United States. He has lately returned to this city, and, in the estimation of good judges, bids fair to be an honour to his country.

a Though the institution of the *Academy of the Fine Arts*, in the city of New-York, does not belong to the century under review; yet the author cannot avoid taking notice of it in this place, as an event which marks the growing taste of our citizens, does honour to the gentlemen who have exerted themselves in forming and executing the plan, and bids fair to be one of the most elegant and interesting ornaments of the city.

CHAPTER XI.

PHYSIOGNOMY.

PHYSIOGNOMY, considered with respect to the feelings, and the experience of mankind, has been an object of attention in all ages. The countenance and general exterior have always been regarded as furnishing some indication both of the intellectual and moral character. Every one who goes into society, and who observes at all, must receive impressions of this kind involuntarily and without design. It may even be said, that the first dawnings of perception and reasoning in children exhibit abundant proof, that some relation between the dispositions of the mind, and the features of the countenance, is recognized and understood by them. So far, then, Physiognomy has been an object of attention, and of some inquiry in all stages of human knowledge.

The first time we hear of this subject being studied as a science, is about the time of PYTHAGORAS. It is said to have been much cultivated in Egypt and India when that philosopher visited those countries, and to have been brought by him into Greece. In the time of SOCRATES physiognomy was studied and adopted as a profession.[b] PLATO speaks of it as attended to by the students of nature in his day. But the first distinct and formal treatise on the subject is by ARISTOTLE, whose work, as it displays the power of his great mind, so it may be considered as the guide to all subsequent inquiries, and the basis of every phy-

b The story of ZOPHYRUS, who undertook to decide on the character of SOCRATES, by inspecting his countenance, is well known.

siognomical treatise that has since appeared. After Aristotle, his disciple THEOPHRASTUS wrote on physiognomy, in a very accurate and interesting manner. He was succeeded by a number of others less conspicuous; and, indeed, at every period of the history of Greece and Rome, when learning was cultivated, in any considerable degree, we hear something of men who employed themselves in investigating and teaching this science.

But when the Roman Empire was overthrown by her Northern invaders, and when, in the general wreck, the various departments of philosophy were buried in forgetfulness, physiognomy also became, in a great measure, neglected and forgotten, as a specific object of study. For a number of centuries we hear little or nothing about it. At the beginning of the sixteenth century we find it again exciting some attention, and from that time till near the close of the seventeenth, it continued to be a general and fashionable subject of inquiry. Within that period the writers on physiognomy were very numerous, and some of them respectable and instructive.

There was one circumstance, however, connected with the study of physiognomy, within the period last mentioned, which served to throw it into a kind of temporary disgrace, and which certainly retarded its progress. For more than two centuries after the revival of learning, the arts of *Magic*, *Alchemy*, and *Judicial Astrology* were fashionable pursuits, and were interwoven with almost every other object of study. Unfortunately physiognomy was rarely spoken of, or investigated but in connection with those play-things of ancient folly, now so justly ridiculed and exploded. From the middle of the seventeenth century we may date the downfal of the reign of alchemy and astrology, and with them, as one of the sciences

denominated *Occult*, physiognomical inquiries for a time also declined.

Philosophers, however, soon learned to distinguish between the science itself and that perversion of it which had arisen from an unnatural connection. Accordingly, early in the century under consideration, it was taken notice of respectfully by Dr. GWITHER;[c] and afterwards, in a still more pointed and able manner by Dr. PARSONS.[d] Besides these British writers, LANCISIUS, of Italy; HALLER, of Switzerland; and BUFFON, of France, published observations on certain branches of the subject, which it is scarcely necessary to say were ingenious and interesting. But the first discussion relating to the science of physiognomy, in the eighteenth century, which excited much attention, was that which took place in 1769, between M. PERNETTY and M. LE CATT, and recorded in the *Memoirs of the Academy of Sciences.*[e] Both these gentlemen contended for the reality and importance of the science; but differed widely with respect to its principles and extent. And though, probably, neither was entirely correct in his views, yet they doubtless contributed to increase the knowledge and study of the subject.

In a short time after the discussion in France had been laid before the public, the great and far-famed work of M. LAVATER, Dean of Zurich, appeared. The opinions respecting physiognomy which he had been for some time divulging in conversation, and disseminating in fragments, were collected by him and his admirers into formal and extensive volumes. This is certainly the most splendid and interesting work on the subject that was ever published; and the deep and general at-

c *Philosophical Transactions*, vol. xviii.

d *Human Physiognomy explained*, 1747.

e *Mem. Acad. Scien.* 1769, Mem. 4th and 5th.

tention which it has excited is well known. Not only in Switzerland, but in Germany, in France, in Great-Britain, and indeed throughout the literary world, it has been read with a degree of ardour and admiration, seldom bestowed on the productions of genius. It has been translated into various languages; passed through an astonishing number of editions; and though now somewhat diminished in popularity, is still perused with high respect and pleasure. That the illustrious Swiss is enthusiastic, fanciful, and visionary; that his works exhibit a singular mixture of wonderful discernment, plausible conjectures, and laughable dreams; and that he gives an extension and importance to the subject which few will allow, seems to be generally admitted by his judicious readers. That he carries his principles to an extreme, and attempts to confer upon his rules a definiteness and precision little short of ridiculous, is also evident. Still there is, doubtless, much reality and justness in his system. And he often displays the refined accuracy of a most delicate observer, together with the enlightened views of a real philosopher.[f]

The method of illustrating physiognomical discussions by *Engravings*, was first adopted by BAPTISTA PORTA,[g] one of the earliest writers on the subject, after the revival of letters. The engravings of M. LAVATER are more numerous, better executed, and, consequently, far more instructive than his. Since the labours of this amiable, pious, and ingenious divine, nothing has been done in the science of physiognomy worthy of being recorded as new. All, therefore, relating to this subject, that can be considered as peculiar to

f See his *Essays on Physiognomy*. Some account of his mode of thinking and reasoning on the subject may also be found in the *Encyclopædia*, from which many of the facts above stated are collected.

g A philosopher of *Naples*, who flourished about the middle of the sixteenth century.

the eighteenth century, is the revival of attention to it; the detaching it from the disgraceful connection in which it had previously stood; and the exhibition of its principles in a more popular and splendid manner. But sanguine calculators imagine that a foundation has been recently laid for incomparably greater progress. They look forward to the time, when the students of this science shall carry it to a degree of perfection of which faint ideas only can now be formed; when its principles shall be so clearly defined, our knowledge of its laws so greatly extended, and departments, at present unknown, so fully laid open to the prying eye of philosophy as to render it one of the most safe standards of judgment, and one of the best guides of action. In short, many have spoken of it as a science susceptible of mathematical certainty, and as capable of endowing man with a power little short of complete intuition into the hearts, intentions, and talents of his fellow-men.

It may well be doubted whether these anticipations be not altogether extravagant and vain. To set bounds to the progress of science is impossible. We can only say, that its cultivators and improvers being finite creatures, there must be limits somewhere beyond which they cannot hope to advance. And though some further improvements in physiognomy may be with reason expected, yet several considerations concur to render it probable, that these improvements must ever fall far short of the point to which many extend their views. Mankind have been long employed in investigating the subject, without making any signal or important advances in their knowledge of its nature and principles. There seems to be little room, in this field of investigation, for those *experiments* and *discoveries*, which have so

brilliantly and profitably abounded in many others. But, above all, to look forward to a period when physiognomy shall be so generally and perfectly understood, as to furnish mankind with a plain and infallible criterion, by which, in all cases, to ascertain precisely the talents and the disposition of each other, is to think of invading the prerogative of Omniscience, and acquiring an instrument subversive of human society. And even if we could suppose such progress in this science within the bounds of probability, we must believe that the arts of concealment, deception, and every concomitant of artifice and false refinement will, at the same time, make equal progress, and thus leave us in the same relative situation as at present.

ADDITIONAL NOTES.

The author had no opportunity of putting his manuscript into the hands of even a single friend, before it was committed to the press. Indeed, a great part of it was prepared only in small portions, as called for by the printer, and frequently amidst the hurry and fatigue of other employments. The printed sheets, however, have been submitted to the perusal of some friends, who were good enough to make a number of remarks, which would probably have been more numerous had time been afforded for a more attentive examination. These remarks, together with the result of the author's more attentive reading, and second thoughts, he thinks proper to annex in the following notes.

NOTES ON CHAPTER I.

Hutchinsonian Philosophy. p. 15.

THE following compendious view of the system of J. HUTCHINSON, Esquire, as it respects Natural Philosophy, is extracted from *a Letter to a Bishop, concerning some important Discoveries in Philosophy and Theology*, by the Right Honourable DUNCAN FORBES, President of the Court of Session in Scotland. As this gentleman appears to have been favourable to the *Hutchinsonian* Philosophy, and had doubtless devoted much attention to it, he may be supposed by some to give a more satisfactory account of it than that which is exhibited in the page above referred to.

"The first thing that is met with in the books of *Moses* is an assertion that God created the heavens and the earth, which is followed by a particular account of the order and manner of the formation of all that was created, till the work was perfected. After which, God is said to have rested; and our author asserts, that it is also said, the perfect machine, then left to itself, carried on all the operations in this system, by certain known laws of mechanism, explained by *Moses*, and throughout the Scriptures by the other inspired penmen.

"The sum of what our author avers to be the doctrine of the Scriptures, on this head, is, that, besides the differently

formed particles, of which this earth, and the several metals, minerals, and other solid substances in it, and in the other solid orbs, are composed, God at first created all that subtile fluid which now is, and from the creation has been, in the condition of fire, light, or air, and goes under the name of the Heavens.

"The particles of this fluid (which our author calls atoms), when they are single and uncompounded, are inconceivably minute, and so subtile as to pervade the pores of all substances whatever, whether solid or fluid, without any great difficulty or resistance: when they are pushed forward in straight lines, by the action of fire, or are reflected or refracted in straight lines, they produce light, and are so called; but when the interposition of any opaque body hinders their progress in straight lines, they pass, but cease to produce light.

"These particles or atoms, which, when moving in straight lines, produce light, and, if collected and put into another sort of motion, would produce heat and fire, are, as our author insists, when the force impelling them ceases to act with vigour, and when their motion is retarded, so made, that they are apt to adhere in small masses or grains, which the author calls spirit or air, and is of the same kind and texture with that air which we daily breathe, and which we feel in wind when it blows.

"The sun, which our author places at the centre of this system, is an orb included in a vast collection of this subtile matter in the action of fire, which continually melts down all the air that is brought into it by the powerful action of the firmament or expansion, hereafter to be explained, into the subtile matter just mentioned; and with an immense force sends forth, in perpetual streams of light, this same subtile matter, so melted down, to the circumference of this system, which the author says is bounded, as he avers the space comprehended within it is absolutely full.

"The matter thus melted down at the orb of the sun into light must, as every thing is full, either stand still or make its way outwards to the circumference, being forced by the particles which are concreted into air at the utmost extremities; and return towards the sun, where the fluid being most subtile, gives least resistance, and take up the place that the light left.

"And therefore this endless uninterrupted flux of matter from the sun in light, in place of being an expense that should destroy that orb (which our author takes to be an insuppor-

able objection to Sir *Isaac Newton's* scheme) is the very means of preserving it, and every thing else in this system, in its action and vigour, by pressing back perpetual supplies of air to be melted down into light, and thereby produces a continual circulation. These perpetual fluxes or tides of matter outwards and inwards, in every point, from the centre to the circumference, mechanically, and necessarily, as our author insists, produce that constant gyration in the earth and the planets round their own centres, and round the sun; and he avers, though he has not yet thought fit to explain it, that the same principle, with some circumstances, arising from the situation and fluxes of light coming from the other orbs, will account also for the motions of the moon.

" Besides the rotation of the orbs, the author affirms that the adverse motions of the light pushing towards the circumference, and the air pushing towards the centre with immense force, form a general expansion (as he translates the word rendered firmament) which brings that stress or compressure on all bodies it meets with, that binds together solids, keeps fluids as they were, causes the variation of times and seasons, the raising of water, the production of vegetables and animals, and, in short, produces all the effects falsely ascribed to gravity or attraction; continues motion without the assistance of the unmechanical principle of projection; produces, supplies, and supports vegetables, fruits, and animals; in short, produces almost all the effects and phænomena in nature."

Parkhurst, Horne, and Jones, *Hutchinsonians*. p. 17.

In this passage I have scarcely done justice to these truly learned, pious, and excellent divines of the Church of England, in representing them, without qualification, as having adopted the philosophy of Hutchinson. Though they all went a considerable length in embracing the opinions of that singular man; yet they were none of them *thorough Hutchinsonians*. Perhaps the most satisfactory information on this subject may be obtained from the perusal of Mr. Jones's *Memoirs of the Life, Studies and Writings* of Bishop Horne.

The philosophical works of the Rev. Mr. Jones deserve to be mentioned with great respect, in this class of writings which belong to the eighteenth century. On a variety of subjects I am far from agreeing with him in opinion; but his learning, his ingenuity, his love of truth, and particularly

the zeal and success with which he shows the consistency between true philosophy and revelation, entitle him to the veneration and gratitude of all good men.

In representing both the knowledge and the admiration of HUTCHINSON'S voluminous writings, as having nearly disappeared before the end of the century, it is possible that the fact is stated rather too strongly. It is believed, however, that very *few* gentlemen now living in Great-Britain, who hold a respectable rank in the scientific world, either embrace the opinions of HUTCHINSON, or study his works.

It is not easy to account for the prejudices entertained by HUTCHINSON and his followers against the philosophy of NEWTON, as if it were hostile to revelation; and, above all, for the suspicion indulged by him, that Sir ISAAC and Dr. CLARKE had formed a design, " by introducing certain speculations, founded on their new mode of philosophising, to undermine and overthrow the theology of scripture, and to bring in the heathen *Jupiter*, or the stoical *Anima Mundi* into the place of the true God." It is believed that nothing was further from the minds of those great men, than to represent matter as possessing inherent *activity*. If any who profess to be their followers be chargeable with falling into this error, none can be too severe upon the atheistical tenet. In the Newtonian system the *attraction* ascribed to all matter is not an *independent principle* or *agent*, but simply a *fact*, referred for its first and continued existence to the immediate power of God. If either class of philosophers be chargeable with going too far in attempting to ascertain *causes*, and in ascribing *agencies* to material objects, it appears to me to be the *Hutchinsonians*.

BOSCOVICH. p. 19.

ROGER JOSEPH BOSCOVICH was born at Ragusa, May 11, 1711, and died at Milan, February 13, 1787. His learning and talents are universally acknowledged. And he is represented as " unstained in his morals, sincerely attached to the Christian religion, and exact in the performance of all Christian duties, as became a Catholic priest." His publications on *Mathematics*, *Optics*, *Astronomy*, *Hydronamics*, &c. render him one of the most distinguished men of the age.

The friends of the *Theory of Natural Philosophy* laid before the public by this celebrated Italian, speak of it in the highest terms, and consider it as one of the noblest efforts of

modern genius. It has been substantially adopted, by Mr. MITCHEL, of Great-Britain, by Dr. PRIESTLEY, and by some other distinguished writers on the physical sciences, who all regard it as relieving philosophy from many pressing difficulties, and opening the way to much new and important light. One great objection to this system immediately presents itself to the mind, and has been forcibly urged against it, viz. If every particle of matter be strictly *inextended*, wherein does it differ from that *ens rationis*, a mathematical point, *without parts or magnitude?* or rather, wherein does it differ from a mere point of *space?* Will not the adoption of this system conduct its advocate a step further, and lay him under the necessity of denying the *real* existence of a *material world*, and of supposing that what we call by that name is a mere system of *attractions* and *repulsions*, without any *substance* in which they can inhere? It is proper to observe, that BOSCOVICH was aware of this objection, and answered it by denying that *extension* is a necessary attribute of matter. But is not this a *petitio principii?* And if it be admitted, we may well ask, wherein does *matter*, according to this philosopher, differ from *spirit?*

LEIBNITZ had taught before BOSCOVICH that the first principles of matter are *inextended points*. The principal difference between the *monads* of the former, and the *inextended atoms* of the latter, lies in the qualities or forces with which they are represented as endowed. The *attractive* and *repulsive* powers of BOSCOVICH differ materially from the *active* and *perceptive* powers of LEIBNITZ, which he considered as sufficient not only to actuate the *monad* at a particular point of time, but also to produce all the changes which it undergoes from the beginning to eternity.

BOSCOVICH seems to have been the first of mankind who rejected all *immediate contact* between bodies, and their constituent particles. In this way he got rid of the difficulty of supposing an *extended* substance to be made up of *inextended* points. LEIBNITZ, by not resorting to the same bold doctrine, left this difficulty lying in all its force against his system.

ELECTRICITY. p. 25.

My friend, PETER WILSON, LL. D. the learned and excellent Professor of the Latin and Greek Languages in Columbia College, has suggested to me that, in detailing the expe-

riments and discoveries of Dr. FRANKLIN, in Electricity, I have scarcely done justice to his friends and coadjutors in this inquiry, particularly Mr. EBENEZER KINNERSLEY, who made several valuable discoveries, and many new experiments. This remark appears to be so just, that I cannot avoid taking some notice of it. The reader who is desirous of seeing what is due to Mr. KINNERSLEY, for the important aid which he afforded to Dr. FRANKLIN in his investigations, will do well to peruse the *Experiments and Observations on Electricity*, &c. by BENJAMIN FRANKLIN, LL. D. and F. R. S. London. 4to. 1769. In this work the Doctor makes many acknowledgments to Mr. KINNERSLEY, as also to his friends, Mr. THOMAS HOPKINSON, Mr. PHILIP SYNG, and others.

The following account of experiments on the influence of electricity in forwarding the germination and growth of plants, is extracted from the *Botanic Garden*, part 1. canto i. note.

"The influence of electricity in forwarding the germination of plants, and their growth, seems to be pretty well established, though M. INGENHOUZ did not succeed in his experiments, and thence doubts the success of those of others; and though M. ROULAND, from his new experiments, believes that neither positive nor negative electricity increases vegetation, both which philosophers had previously been supporters of the contrary doctrine; for many other naturalists have since repeated their experiments relative to this object, and their new results have confirmed their former ones. M. D'ORMOY, and the two ROZIERS, have found the same success in numerous experiments which they have made in the last two years; and M. CARMOY has shown, in a convincing manner, that electricity accelerates germination.

"M. D'ORMOY not only found various seeds to vegetate sooner, and to grow taller, which were put upon his insulated table, and supplied with electricity, but also, that silk-worms began to spin much sooner which were kept electrified, than those of the same hatch which were kept in the same place and manner, except that they were not electrified. These experiments of M. D'ORMOY are detailed at length in the Journal de Physique of ROZIER, tom. xxxv. p. 270.

"M. BARTHOLON, who had before written a tract on this subject, and proposed ingenious methods for applying electricity to agriculture and gardening, has also repeated a numerous set of experiments; and shows both that natural electri-

city, as well as the artificial, increases the growth of plants, and the germination of seeds; and opposes M. INGENHOUZ by very numerous and conclusive facts. *Ibid.* tom. xxxv. p. 401.

"Since, by the late discoveries or opinions of the Chemists, there is reason to believe that water is decomposed in the vessels of vegetables; and that the hydrogen, or inflammable air, of which it in part consists, contributes to the nourishment of the plant, and to the production of its oils, resins, gums, sugar, &c. and, lastly, as electricity decomposes water into these two airs, termed oxygen and hydrogen, there is a powerful analogy to induce us to believe that it accelerates, or contributes to the growth of vegetation, and, like heat, may possibly enter into combination with many bodies, or form the basis of some yet unanalized acid."

For a number of years after the experiments of Mr. MAIMBRAY, and the Abbe NOLLET, by which it appeared that electricity had been found to forward the germination and growth of vegetables, there was no doubt entertained of the truth of their doctrine. It remained uncontradicted until Mr. SWANKHARDT published the facts which he had learned from Mr. INGENHOUZ. Since that time the number of sceptics or opposers has increased; and it seems to be now doubtful whether the first experimenters on this subject were not mistaken.—M. SENNEBIER, in a late work, concludes that the influence of the electric fluid on vegetables is at least dubious. —See *Physiologie Vegetale*, &c. tom. iii. p. 399.

Controversy respecting the Franklinian Theory. p. 26.

The principal advocates of the *Franklinian theory*, viz. that all the phenomena of electricity may be accounted for by the different states and operations of *one homogeneous fluid*, are CANTON, LE ROY, PRIESTLEY, HENLEY, BECCARIA, CAVALLO, MORGAN, and several others. To the class of those who reject this theory, and consider the agency of *two electric fluids* as necessary to be supposed, belong SYMMER, EELES, CIGNA, ADAMS, CUTHBERTSON, DARWIN, BROOKE, and several other distinguished writers on this subject.

Those who adopt the opinion that there are *two electric fluids*, are, however, by no means agreed among themselves. Some, as SYMMER, EELES, ADAMS, &c. believe in two

fluids, which operate on each other, and on other bodies, upon *mechanical* principles. They suppose that these are two distinct, positive, and active powers, which equally and strongly attract and condense each other; that they exist together in all bodies, in their natural state, conjoined; but that their electric signs, or what we call electricity, only become sensible in consequence of the separation of these two powers. That, while united, they are latent and invisible; but when separated they become immediately visible and active. These two fluids or powers are called *Vitreous* and *Resinous* electricities.—See EELES's *Philosophical Essays*, 1771, and ADAMS's *Lectures*.

There are others who explain the phenomena of electricity upon *chemical* principles. They also believe in the existence of two distinct and positive fluids; but instead of a *mechanical* operation, they consider all their sensible effects as arising from *chemical* affinity and union. The following theory of Dr. DARWIN may serve as a specimen of chemical electricity. —See *Temple of Nature, Additional Notes*, p. 46. 4to. Lond. 1803.

1. There are two kinds of electric ether, which exist either separately or in combination. That which is accumulated on the surface of smooth glass, when rubbed with a cushion, is here termed *vitreous* ether; and that which is accumulated on the surface of resin, or sealing-wax, when rubbed in like manner, is here termed *resinous* ether; and a combination of them, as in their usual state, may be termed *neutral* electric ethers.

2. Atmospheres of vitreous, or of resinous, or of neutral electricity, surround all separate bodies, are attracted by them, and permeate those which are called conductors, as metallic, aqueous, and carbonic substances; but will not permeate those which are called non-conductors, as air, glass, silk, resin, sulphur.

3. The particles of vitreous ether strongly repel each other, but attract the particles of resinous ether, and *vice versa*. When the two electric ethers unite, a chemical explosion occurs, in some respects like that of gunpowder, light and heat are liberated, and rend or fuse the bodies which they occupy.

4. Glass holds within it, in combination, much resinous electric ether, which constitutes a part of it, and which more forcibly attracts vitreous electric ether from surrounding bodies, which stands on it, mixed with a less proportion of resinous ether, like an atmosphere, but cannot unite with the

resinous ether, which is combined with the glass. And resin, on the contrary, holds within it, in combination, much vitreous electric ether, which constitutes a part of it, and which more forcibly attracts resinous electric ether from surrounding bodies, which stands on it, mixed with a less proportion of vitreous ether, like an atmosphere, but cannot unite with the vitreous ether which is combined with the resin.

5. Hence the non-conductors of electricity are of two kinds, and opposite to each other; the one class of the vitreous, the other of the resinous. But the most perfect conductors, such as metal, water, and charcoal, having neither kind of electric ether *combined* with them, though *surrounded* with both, suffer both kinds to pass through them easily.

6. Great accumulation or condensation of the separate electric ethers attract each other so strongly that they will break a passage through non-conducting bodies. Hence trees and stone walls are rent by lightning.

7. When artificial or natural accumulations of these separate ethers are in very small quantity or intensity, they pass slowly, and with difficulty, from one body to another, and require the best conductors for this purpose. Whence many of the phenomena of the *Torpedo*, or *Gymnotus*, and of *Galvanism*.

8. The electric ethers may be separately accumulated by the contact of conductors with non-conductors—by vicinity of the two ethers—by heat—and by decomposition.

9. When these two ethers unite suddenly, and with explosion, a liberation of light and heat takes place, as in all chemical explosions. Accordingly it is said that a *smell* is perceptible from electric sparks, and even a *taste*, which must be supposed to arise from new combinations or decompositions.

The theory founded on the principles above stated is supposed, by those who adopt it, to solve many difficulties which can scarcely be accounted for on the theory of FRANKLIN. To say that the former mode of accounting for the electrical phenomena will probably be found the true one, would be, in the present state of our knowledge, to pronounce rashly; but if this subject should ever be developed, it will probably be found that *Electricity* ought to be considered as a branch of *Chemistry;* that its phenomena result from the union of two substances, by the chemical combination of which explosion is produced, and light and heat are liberated.

Dr. Gibbes, of Great-Britain, also adopts a chemical theory of electricity. He supposes that oxygen gas is produced by the union of *positive electricity* with water; and hydrogen gas by the union of *negative electricity* with water; and that water, uniting in different proportions with the two electricities, is the ponderable part of all the elastic fluids. He asserts that, by the *positive electricity*, metals are oxydated, and blue vegetable colours reddened; and also that the acidifying effect of electric commotions in the atmosphere, on weak fermented liquors, is unquestionable. On the other hand, according to this writer, by *negative electricity* the vegetable blue is restored, and the oxydated metal revived.

These circumstances, among others, lead Dr. Gibbes to conclude that, when hydrogen gas is produced by the affusion of water on red-hot metal, and the metal is at the same time oxydated, a decomposition of *fire* rather than of *water* has taken place; that the hot metal has parted with negative electricity, which, uniting with a small proportion of the water, has formed hydrogen gas; that a greater proportion of the water has united with the positive electricity, and entered, as oxygen gas, into combination with the metal. When the two gases are inflamed together, the spark attracts to itself, in due proportions, the two electricities contained in the two gases, which unite with explosion, and produce fire. The water with which they were before combined is of course deposited.

The reason why inflammable substances burn in oxygen gas, and not in hydrogen, Dr. Gibbes supposes to be that negative electricity greatly prevails in all inflammable substances. Neither of the gases can be inflamed separately, because fire depends on the union of the two electricities; and such union cannot be effected unless both are present in due proportion.

Dr. Gibbes supposes that the further illustration of the effects of the two electricities as chemical agents, will set aside some of the leading doctrines of the Lavoisierian theory, and afford an easy solution of certain phenomena which that theory cannot explain.

It is a curious fact that Dr. Gibbes, in supposing that *oxygen* gas is produced by the union of *positive electricity* with water, and that *hydrogen* gas is produced by the union of *negative electricity* with water, was anticipated by Dr. Priestley.—See his letter to Dr. Woodhouse, Sept. 16, 1801, in the *Medical Repository*, vol. v. p. 158.

ÆPINUS's *Theory of Electricity*. p. 26.

Mr. ÆPINUS, of the Imperial Academy of St. Petersburgh, has attempted to class the phenomena of *Electricity* and *Magnetism* in a mathematical method. In the course of his work he gives some views of the subject, which are new, and highly ingenious, and, as some good judges suppose, calculated to surmount many difficulties, and to answer many questions which occur in considering the Franklinian theory.—The leading principles of his plan are comprehended in the following propositions.

The phenomena of electricity are produced by a fluid of peculiar nature, and therefore called the *Electric fluid*, having the following properties.

1. Its particles repel each other with a force decreasing as the distances increase.

2. Its particles attract the particles of some ingredients in all other bodies, with a force decreasing, according to the same law, with an increase of distance; and this attraction is mutual.

3. The electric fluid is dispersed in the pores of other bodies, and moves with various degrees of facility through the pores of different kinds of matter. In those bodies which we call *non-electrics*, such as water, or metals, it moves without any perceivable obstruction; but in glass, resins, and all bodies called *electrics*, it moves with very great difficulty, or is altogether immoveable.

4. The phenomena of electricity are of two kinds:—1. Such as arise from the actual motion of the fluid from a body containing more, into one containing less of it. 2. Such as do not immediately arise from this transference, but are instances of its attraction and repulsion.

These principles are applied at great length, and with a pleasing degree of precision, by the ingenious theorist, to the *Leyden Phial*, and to the various phenomena of electric attraction and repulsion. It will be readily seen that ÆPINUS adopts, in substance, the theory of FRANKLIN, of which, in some particulars, he presents new and more satisfactory views than the American philosopher. In the sixty-first volume of the *Philosophical Transactions* there is a *Dissertation*, by the Hon. Mr. CAVENDISH, on this subject, which he considers as an extension and more accurate application of ÆPINUS's theory.

GALVANISM.

Gymnotus Electricus, Torpedo, &c. p. 28.

The *Gymnotus Electricus* is a native of the river of Surinam, in South-America. Those which were carried to England about eight years ago were about three or four feet long, and gave an electric shock, by putting one finger on the back, near its head, and another of the opposite hand into the water near its tail. In their native country they are said to exceed twenty feet in length, and kill any man who approaches them in an hostile manner. It is not only to escape its enemies that this surprising power of the fish is used, but also to take its prey; which it does by benumbing them, and then devouring them before they have time to recover, or by perfectly killing them at once; for the quantity of the power seems to be determined by the will of the animal; as it sometimes strikes a fish twice before it is sufficiently benumbed to be easily swallowed.

The organs productive of this wonderful accumulation of electric matter have been accurately dissected and described by Mr. J. HUNTER, *Philos. Trans.* vol. lxv. and are so divided by membranes as to compose a very extensive surface, and are supplied with many pairs of nerves, larger than any other nerves of the body: but how so large a quantity is so quickly accumulated as to produce such amazing effects in a fluid ill adapted for the purpose, is not yet satisfactorily explained. The *Torpedo* possesses a similar power in a less degree, as was shown by Mr. WALCH, and another fish lately described by Mr. PATERSON. *Phil. Trans.* vol. lxxvi. *Botanic Garden*, Part I. Canto i. p. 12, note.

Late Discoveries in Galvanism. p. 30.

Four epochas may be observed in the history of Galvanism, each of them distinguished by the developement of important facts. The *first* was formed by the publication of the fundamental Galvanic fact, viz. the production of muscular contraction by the application of metals to the nerves and muscles of animals, and which was entirely limited to organized bodies. The *second* may be derived from the discovery of the Galvanic influence in inorganic matter. The

researches of FABRONI, Dr. ASH, and CREVE, exhibiting the peculiar action of metals in contact with each other upon water, demonstrated the production of the Galvanic influence in combinations wholly composed of inorganic matter, and thereby connected it with the general principles of physics. The *third* epocha in the history of Galvanism is founded on the discovery of the means of accumulating this influence by the *battery* or *pile* of VOLTA, which paved the way for a distinct exhibition of the analogy between Galvanism and common Electricity. The *fourth* arises from the discovery of the *chemical* agencies of Galvanism. In the prosecution of this last train of inquiry, the principal degree of praise is due to the British experimenters, and, among these, chiefly to Messrs. CARLISLE, NICHOLSON, CRUICKSHANK, HALDANE, HENRY, and more particularly to Mr. DAVY and Dr. WOLLASTON.

Messrs. CARLISLE and NICHOLSON did much towards establishing the electricity of the pile, by ascertaining that it is *minus* in the silver end, and *plus* in the zinc end. They also demonstrated its chemical action, especially in the decomposition of water; a most interesting experiment, which has led to many very important results.

Mr. CRUICKSHANK was the first discoverer of the Galvanic production of *alkali*. In his experiments he supposed *ammoniac* to be generated; while, according to those of some others, the alkali produced was thought to be fixed. He likewise invented the mode of placing the metals horizontally in a kind of trough, which, in several respects, is much more convenient than the apparatus of VOLTA. And he was the first who succeeded in charging the Leyden phial by means of the Galvanic pile.

Mr. WILLIAM HENRY ascertained, by his experiments, that the sulphuric and nitric acids may be decomposed by the operation of the Galvanic influence; but, in his attempts on the muriatic acid, he only succeeded in decomposing the water adhering to it. He also demonstrated that ammoniac may be decomposed in a similar manner.

Col. HALDANE found that the effects of the apparatus of VOLTA were suspended when it was immersed in water; and that this likewise was the case when it was confined in azotic gas, or placed under the vacuum of an air-pump. He observed that the pile acted more powerfully when immersed in a given quantity of oxygen gas than in the same bulk of atmospherical air.

Dr. WOLLASTON has greatly contributed to enlarge our knowledge of the nature and principles of Galvanism. He read an excellent paper on this subject to the Royal Society, which appeared in their *Transactions* for the year 1801. After stating a variety of experiments most ingeniously devised, and cautiously as well as accurately conducted, he advances his induction, from a great number of distinct and luminous proofs, that the phenomena of Electricity and Galvanism are all results of the same principle.

But scarcely to any one in Great-Britain is Galvanism more indebted for its extension and improvement than to Mr. DAVY, of the Royal Institution. Among many other discoveries of less importance, which the rapidity of this sketch does not allow to be mentioned, he first ascertained the fitness of *charcoal*, when used with silver, as a conductor of the Galvanic influence. He discovered that a pile may be constructed with one metal only, provided proper fluids of different kinds be applied to its different surfaces. And he found that a similar result takes place with respect to charcoal alone, if a like diversity in the fluids applied to its different surfaces be duly observed. Mr. DAVY also discovered that the energy of the pile is nearly in proportion to the rapidity with which the zinc becomes oxydated; and, consequently, that the effects will be found to be the most powerful when nitric acid is interposed between the metals. This seems to be one of the first steps towards the true theory of the action of VOLTA's pile.

Most of the improvements by the British philosophers above-mentioned were communicated to the public in the course of the year 1801; a year very memorable for the number, variety and importance of the additions made to the stock of knowledge in this science.

Roused by the success and eclât of the British discoveries which have been just detailed, the votaries of this science on the continent of Europe soon began to furnish their additional contributions.

TROMSDORFF found that gold leaf, and other metallic leaves, may readily be subjected to combustion by being fixed to the zinc end of the wire of VOLTA's pile.

FOURCROY made the remarkable discovery, that the *shock* is greater in proportion to the accumulation of the *number of plates* in the pile, and the *combustion* in proportion to the *extent of their surface*.

Dr. VAN MARUM, of Holland, and Professor PFAFF, of

Kiel, succeeded in charging *electrical batteries* of 140 feet square, by a single contact with the pile of VOLTA, and proved that this pile is a true excitatory apparatus of electricity. They melted, by the electricity of this apparatus, a large portion of iron wire, and even wire of *platina.* The communication of Dr. VAN MARUM on this subject, to Sig. VOLTA (see *Annales de Chimie*, tom. 40), is highly interesting. He charged both single jars and large batteries by means of the pile, and always found that they were charged to the same degree of intensity with that which the pile itself indicated to the Electrometer. He found, also, that the shocks given by the battery, when charged from powerful electrical machines, were not perceptibly different from those given by batteries charged from the pile. He found, further, that piles which consist of the same *number* of plates, but of different *diameters*, gave equal intensities and equal shocks; but that those made of larger plates are considerably more powerful in fusing metals.

Dr. BOSTOCK'S *Theory of Galvanism.*

JOHN BOSTOCK, M. D. of Great-Britain, has offered the following Galvanic theory:—He thinks that the phenomena of the pile of VOLTA may all be easily explained by admitting the truth of the following *postulates.*

1. That the electric fluid is always generated or liberated when a metal, or any oxydable substance, is united to oxygen.
2. That the electric fluid has a strong attraction for hydrogen.
3. That when the electric fluid, in passing along a chain of conductors, leaves an oxydable substance to be conveyed through water, it unites itself to hydrogen, from which it is again disengaged, when it returns to the oxydable conductor.

The *first* of these propositions Dr. BOSTOCK considers as almost proved by the experiments of FABRONI, DAVY, and WOLLASTON. The *second* and *third* have not been directly established by experiment, but are viewed by Dr. BOSTOCK as highly probable.

Dr. BOSTOCK accounts for the operations carried on at the end of the wire, in the interrupted circuit, as discovered by NICHOLSON, in the following manner.

As the current of the electric fluid appears to pass from the zinc, or *plus* end of the apparatus, to the silver end, it

is first proper to ascertain the action which takes place at the zinc end of the wire. This appears to be the disengagement of oxygen in a concentrated state, by which the wire itself, when oxydable, is corroded, but which, when the wire is formed of a perfect metal, is disengaged in the form of oxygen gas. This oxygen appears to be derived from the decomposition of the water in which the wire terminates, in consequence of the attraction which the electric fluid possesses for hydrogen, and its incapacity of passing through water without being united to this substance, according to the second and third *postulates*. The electric fluid, thus united to hydrogen, is carried to the other point of the wire, where, upon entering the oxydable conductor, it is disengaged in the form of hydrogen gas, if water be the medium of communication. If a solution of metallic oxyd be employed, it unites with the oxyd, and reduces it. The decomposition of water is, therefore, effected at the zinc point alone, though the different gases which compose it are disengaged at each of the points; and the process will continue even when the points terminate in two different portions of water, as was discovered by Mr. DAVY, provided that the glasses are united by a conductor which is not oxydable.

To explain the operation carried on in the body of the pile itself, Dr. BOSTOCK says—

In the construction of the pile there are two points which are essential to its action; viz. 1. That the electric fluid be disengaged; and, 2. That it be confined and carried forward in one direction, so as to be concentrated in the end of the apparatus. The first object is evidently attained by the oxydation of the zinc, or other oxydable body employed. If both sides of the zinc wére oxydated, the electric fluid would, indeed, be liberated, but it would be immediately dispersed, and its effects could not be observed. As soon, however, as the electric matter is evolved, it is immediately attracted by the hydrogen, which is, at the same time, necessarily generated in the fluid which oxydates the metal; and it is by this means conveyed across the water to the silver plate, when two metals are used, or, in other cases, simply to the opposite surface of the oxydating substance. The electric fluid then enters the silver plate, and, instantly passing on to the contiguous zinc plate, arrives at a second oxydating surface. The same series of events that have been described is here repeated, except that the electric fluid being in some degree accumulated in the metallic plate, is disengaged by the second

oxydating surface in larger quantity, and in a more concentrated state than before. By pursuing the same train of operations, it is easy to see how the electric matter will continue to be accumulated in each successive pair of plates, until, by sufficient repetition, it may be made to exist, in the zinc end of the pile, in any assigned degree of force.

The analogy between Galvanic phenomena and many circumstances connected with muscular action, and other processes of vitality, began, several years ago, to make an impression on the minds of many who engaged in the pursuit of this science. The appearance of Galvanic action in living animals, such as the *Torpedo*, &c. was found strongly to confirm this impression. Organized beings contain all the substances necessary for the formation of Galvanic arrangements; and chemical changes are continually going on in different parts of the living body, which are probably connected with variations in their states of electricity. These circumstances, together with the original Galvanic fact, of the production of muscular contraction when the influence was applied, and the dependence of irritability, and even life, upon the oxygenation of the blood, served to strengthen the analogy.

These speculations seem to have been reduced almost to demonstration by some recent experiments. Professor ALDINI, of Bologna, is supposed to have decisively shown, that a vital attraction subsists between a nerve and muscle. The suspended sciatic nerves of a frog, after detaching the spine, being brought near the intercostal muscles of a dog, while the assistant who held the frog, with his other hand, touched the muscles of the thigh of the dog (thus forming a circle); in this situation the suspended nerves approached and came into contact with the muscle, as evidently as a silken thread is attracted by sealing-wax. But a still more important fact was that of exciting contractions by making a circle of nerves and muscles, of different animals, without employing any metallic exciter or conductors. M. CIRCAUD found that the coagulum of blood recently drawn from a living animal is susceptible of the Galvanic stimulus, as appeared from contractions evidently excited by the pile of VOLTA. And M. GARVE formed a kind of pile, by alternate pieces of muscle and brain, with the intervention of pasteboard or cloth, which produced, in some small degree, similar phenomena with those of the common pile.

Identity of Electricity and Galvanism. p. 31.

There appears to be now no longer any doubt that the Galvanic and electric fluids are the same, differing in the means of their excitement, and in the modes of their exhibition. Besides the evidence arising from the celebrated experiment of VAN MARUM, in which a large electrical battery was charged by a single contact with the pile of VOLTA, as before stated, we find, among the Galvanic phenomena, indications of the *plus* and *minus*, or the negative and positive operation, which holds so important a station among the doctrines of electricity: we find also the electric *spark*, and substantially the same results, on employing the *Condenser* of electricity and the *Electrometer*. The interesting experiments of Dr. WOLLASTON, before-mentioned, tend strongly to the establishment of this point. He even found that, when common electricity is passed through water, by means of two very fine metallic points, chemical changes are effected by it, similar to those occasioned by the transmission of the Galvanic influence.

It is scarcely necessary to add, that the most able experimenters on the subject of Galvanism are as unanimous in considering this fluid as an important *chemical* agent.—"That a strong chemical action takes place among the substances composing the pile of VOLTA is clearly proved, since one of the metals is always *oxydated*, and the saline solution employed to moisten the pasteboard is decomposed; and that this action is intimately connected with the excitation of the electric energy, is established by numerous experiments. The power of the apparatus ceasing when it is placed in the exhausted receiver of the air-pump, or in a vessel filled with azotic or hydrogen gas, strongly illustrates this point. When it is considered, also, that the apparatus is more powerful in oxygen gas than in the atmospheric air, and that in either the oxygen is consumed; and that its powers are much increased when the water in contact with the metal holds in solution oxygen, nitrous gas, diluted nitric or muriatic acid, or any substance which either affords oxygen with facility, or promotes the oxydation of the metal, the evidence of strong chemical action will be viewed as still more unquestionable. The power of the Galvanic series or column seems, indeed, to be proportioned to the oxydation of the metal which composes it; and hence it may, with much pro-

bability, be concluded, that it is to this chemical action that the excitation of the Galvanic influence is owing."

Those who wish to see a more detailed account of the history of Galvanism, especially of the numerous and very interesting experiments and discoveries made in this branch of philosophy, in the years 1801 and 1802, will do well to consult the *Philos. Trans.* for 1801, TILLOCH's *Philos. Mag.* and NICHOLSON's *Journal of Natural Philosophy.*

MAGNETISM.

Artificial Magnets. p. 33.

"As every piece of iron which was made magnetical by the touch of a magnet became itself a magnet, many attempts were made to improve these artificial magnets, but without much success, till SERVINGDON SAVERY, Esq. of Great-Britain, made them of *hardened steel bars*, which were so powerful, that one of them, weighing three pounds averdupois, would lift another of the same weight.

"After this Dr. GOWIN KNIGHT made very successful experiments on this subject, which, though he kept his method secret, seems to have excited others to turn their attention to magnetism. About this time the Rev. Mr. MICHEL invented an equally efficacious and more expeditious way of making strong artificial magnets, which he published in the end of the year 1750, in which he explained his method of what he called the *Double Touch*, and which, since Dr. KNIGHT's method has been known, appears to be somewhat different from it.

"This method of rendering bars of hardened steel magnetical, consists in holding vertically two or more magnetic bars nearly parallel to each other, with their opposite poles very near each other (but, nevertheless, separated to a small distance): these are to be slided over a line of bars, laid horizontally, a few times backward and forward.

"What Mr. MICHEL proposed by this method was, to include a very small portion of the horizontal bars intended to be made magnetical, between the joint forces of two or more bars already magnetical, and, by sliding them from end to end, every part of the line of bars became successively included; and thus bars, possessed of a very small degree of magnetism to begin with, would, in a very few

times sliding backwards and forwards, make the other ones much more magnetical than themselves, which are then to be taken up and used to touch the former, which are in succession to be laid down horizontally in a line."—*Botanic Garden*, Part I. Canto ii. p. 48, note. New-York edit.

Dr. KNIGHT's method of making *artificial magnets*, referred to by Dr. DARWIN in the above-mentioned note, was as follows: He reduced iron to a very subtle powder, made it into a paste with oil, moulded the composition into pieces of a convenient form, dried them before a moderate fire, and then imparted to them the magnetic virtue, by placing them between the extreme ends of his large magazine of artificial magnets, for a few seconds or more, as he thought requisite.

After MICHEL, the manufactory of artificial magnets received further improvements by Mr. CANTON, in 1756, and by M. ANTHEAUME, in 1766.

Magnetical Theory of ÆPINUS. p. 33.

The theory of this celebrated philosopher of St. Petersburgh may be comprised in the following propositions.

1. There exists a substance in all magnetic bodies, which may be called the magnetic fluid; the particles of which repel each other with a force decreasing as the distances increase.

2. The particles of magnetic fluid attract and are attracted by the particles of iron, with a force that varies according to the same law.

3. The particles of iron repel each other according to the same law.

4. The magnetic fluid moves, without any considerable obstruction, through the pores of iron and soft steel: but it is more and more obstructed in its motion as the steel is tempered harder; and in hard tempered steel, and in the ores of iron, it is moved with the greatest difficulty.

5. When the quantity of this fluid contained in iron is such that the accumulated attraction of a particle for all the iron balances, or is equal to, the repulsion of all the fluid which the iron contains, the quantity may be said to be the *natural quantity* of the iron, which may then be said to be in its *natural state.*

6. The magnetic fluid may be abstracted from one end of

a magnetic bar, and constipated in the other, and on this depends the exertion of its force. In other words, the condensation and motion of the magnetic fluid are subject to the same laws, *(mutatis mutandis)* in the opinion of this philospher, as the electric fluid on the Franklinian theory, the motion and sensible signs of which depend on the *plus* and *minus* states, or the deficiency and redundancy of the same fluid in different bodies.

Magnetical Theory of M. PREVOST.

Mr. PREVOST, of Geneva, in a Dissertation on the Origin of Magnetic Forces, expresses a belief that there are *two magnetic fluids*, which, by their union, compose a *third*, which he calls *combined fluid*. These two fluids, he thinks, are both elastic like air; the particles of each attract each other, but those of the other kind most strongly. A strong elective attraction of the combined fluid for iron decomposes part of the fluid in the iron, and each of its ingredients occupies opposite ends of the bar. These bars then approach or recede, according as the near ends contain a different or the same ingredient.—See *Essai sur l'Origine des Forces Magnetiques*. 1788.

Chemical Theory of Magnetism.

Among other attempts to extend the bounds of Chemistry, it has been lately proposed to place the magnetic fluid in the list of its subjects. Accordingly, several writers have considered this fluid as a chemical agent, and explained its phenomena on corresponding principles. Among these, Dr. DARWIN, in the *Additional Notes* to his *Temple of Nature*, proposes the following hypothesis.

1. Magnetism coincides with electricity in so many important points, that the existence of *two magnetic ethers*, as well as of two electric ones, becomes highly probable.

2. In a common bar of iron or steel, the two magnetic ethers (which, for the greater ease of speaking, may be called *arctic ether* and *antarctic ether*), exist intermixed, or in their *neutral* state: in this state, like the two electric fluids, they are not cognizable by the senses.

3. When these two magnetic ethers are separated from

each other, and the *arctic* ether is accumulated in one end of an iron or steel bar, which is then called the north pole of the magnet; and the *antarctic* ether is accumulated on the other end of the bar, which is then termed the south pole of the magnet, they become capable of attracting other pieces of iron or steel, and are thus cognizable by experiments.

4. It seems probable that it is not the magnetic ether itself which attracts or repels particles of iron; but that an attractive and repulsive ether attends the magnetic ethers, as in the case of the electric.

5. While the two electric ethers, when separated by nature or art, combine, by chemical affinity, with explosion, emit light and heat, and leave a residuum; the two magnetic ethers, after being separated in like manner, combine by chemical affinity, but without explosion, and produce, by their union, a neutralized fluid.

Motion and Moving Forces.

Projectiles. p. 37.

Benjamin Robins, of Great-Britain, certainly did more to improve the science of *military projectiles* than any individual, not to say than all other individuals, who had gone before him. He made a great number of well-devised and important experiments; and, in his *New Principles of Gunnery*, left a lasting monument both of genius and labour.

From the experiments detailed in this work, which was published in 1742, it incontestibly appeared, that the resistance made by the air to projectiles, which have a rapid motion, is much greater than had been supposed by Newton and Huygens; that it is, indeed, so great, that the path described by any shot whatever is very different from the curve of a *parabola*, and, consequently, that all applications of that conic section to gunnery are false and useless. Mr. Robins's experiments were made with shot of one ounce weight only: it was, therefore, much to be wished, that such persons as had opportunity might repeat the same experiments with balls of a larger size. Mr. Charles Hutton, of the Royal Military Academy at Woolwich, performed this service to science. He even used in his experiments balls of from *twenty* to *fifty* ounces weight. The result of these experiments confirmed Mr. Robins's principles in the most ample manner.

Mr. ROBINS, however, in estimating the mechanical force of *Gunpowder*, fell into an error, which has been since corrected by our acute and persevering countryman, Count RUMFORD. The former states this force, according to his experiments, to be 1000 times greater than the mean pressure of the atmosphere; while the celebrated DANIEL BERNOULLI determined it to be not less than 10,000 times greater. Such a difference of opinion led Count RUMFORD to pursue a course of experiments, of which some were published in the *Philosophical Transactions* for 1781, and the remainder in the *Transactions* of the same Society for 1797; with the view principally of determining the initial expansive force of Gunpowder. By one of these experiments it appeared that, calculating even on Mr. ROBINS' own principles, the force of Gunpowder, instead of being 1000 times, must at least be 1308 times greater than the mean pressure of the atmosphere. From this experiment the Count thought himself warranted in concluding, that the principles assumed by Mr. ROBINS were erroneous, and that his mode of ascertaining the force of Gunpowder could never satisfactorily determine it. Despairing of success in that way, he resolved to make an attempt for ascertaining this force by actual measurement; and, after many unsuccessful experiments, he was at length led to conclude that this force was at least 50,000 times greater than the mean pressure of the atmosphere.—See RUMFORD'*s Philosophical Essays*, 8vo.

Mr. BENJAMIN THOMPSON *(now Count* RUMFORD). p. 37.

This great practical Philosopher was born, about the year 1753, at Woburn, a small town in Massachusetts, ten miles north of Boston. His parents were in humble life, and his advantages, with respect to education, were small. But he was early distinguished as a lad of spirit and enterprise, and discovered a fondness for knowledge. After spending some time in a retail store in Boston, where he was more fond of amusing himself with a *violin* than of attending on customers, and preferred making experiments with an *electrical machine* to either, he returned to Woburn: here, however, he did not remain long. In 1772 he attended Professor WINTHROP's Lectures on Experimental Philosophy, in Harvard College. He was not a matriculated student, but, being regarded as an ingenious and promising young man, was per-

mitted to attend this part of the usual course of instruction, for which he manifested a particular predilection.

In 1772 or 1773, young THOMPSON went to New-Hampshire, and settled in a town called *Rumford*, at that time under the jurisdiction of Massachusetts, but afterwards, by a new territorial arrangement, assigned to New-Hampshire, and now called *Concord*. Here he married a widow, of the name of ROLFE, with whom he received a large fortune. In 1775 he went to England, and, soon after his arrival, was introduced to Lord GEORGE GERMAINE, then Secretary of State, to whom he so far recommended himself as to be appointed one of the first clerks in his office. When his Lordship went out of office he still exerted his influence in favour of Mr. THOMPSON, and obtained for him a Colonel's commission. With this commission, towards the close of the American war, he came to New-York, with the view of raising a regiment of loyalists; but the regiment was never completed; he was, however, still active in the service of the King, and, soon after the peace of 1783, he returned to England.

Here the proofs of his activity, enterprise, and philosophic acuteness, and particularly of his taste for improvements in military affairs, were so numerous, that he began to attract more public attention than before, and offers were made to him of preferment in foreign service. He at length accepted a flattering invitation given to him by the reigning Duke of *Bavaria*, and went into his service in 1784. By this Prince he was made Lieutenant-General of horse, and soon rendered himself conspicuous by introducing a new system of order, discipline and economy among the troops under his command. He remained a number of years in Bavaria, where he was much distinguished by his successful exertions to destroy mendicity, and to meliorate the condition of the poor, and, by a variety of improvements highly favourable to manufactures, economy and humanity. On leaving the service of the Elector he was created a Count; his title being taken, by his own choice, from the name of the town in America in which he had for some time resided.

Count RUMFORD has chiefly resided, for a number of years past, in Great-Britain, where he has been so much celebrated for his experiments, discoveries and improvements in military, economical, and chemical science, that it is unnecessary to dwell on his merits. Besides the new light which he threw on the subject of *gunnery*, before men-

tioned, the friends of science and humanity are indebted to him for improved methods of constructing *Chimnies* and *Stoves;* for important discoveries and improvements relative to *cookery* and *aliment;* for curious and highly interesting experiments on heat, &c. &c. In short, it seems to be generally agreed, that he stands in the first class, if not at the head, of all the *practical*, and particularly the *economical* philosophers, now living.

He was *knighted* by the King of Great-Britain in 1784, and has received many honourable testimonies of public and private respect in that country. His only child, a daughter, now resides in the town of Boston.

PNEUMATICS.

PRINCE's *Air-Pump.* p. 45.

The improvement on SMEATON's Air-pump, by the Rev. Dr. PRINCE, of Salem, in Massachusetts, is worthy of particular notice, and of much praise. Good judges have pronounced it to be the most simple, convenient, and powerful of all the different kinds of this machine now in use. A distinct account, however, of the several points of which this improvement consists would lead to a minuteness and extent of detail inconsistent with the necessary limits of this note. The author regrets that this circumstance prevents his attempting to exhibit the merits of Dr. PRINCE's machine.

Balloons. p. 45.

In 1729, BARTHOLOMEW GUSMAO, a Jesuit, of Lisbon, caused an aërostatic machine, in the form of a *bird*, to be constructed, and made it to ascend, by means of a fire kindled under it, in the presence of the king, queen, and a great concourse of spectators. Unfortunately, in rising, it struck against a cornice, was torn, and fell to the ground. The inventor proposed renewing his experiment, but the people had denounced him to the Inquisition as a sorcerer, and he withdrew into Spain, where he died in an hospital.

Steam-Engines. p. 47.

" The expansive force of steam was known, in some degree, to the ancients. Hero, of Alexandria, describes an application of it to produce a rotative motion by the re-action of steam issuing from a sphere mounted upon an axis, through two small tubes bent into tangents, and issuing from the opposite sides of the equatorial diameter of the sphere; the sphere was supplied with steam by a pipe communicating with a pan of boiling water, and entering the sphere at one of its poles.

" A French writer, about the year 1630, describes a method of raising water to the upper part of a house, by filling a chamber with steam, and suffering it to condense of itself; but it seems to have been mere theory, as his method was scarcely practicable as he describes it. In 1655, the Marquis of Worcester mentions a method of raising water by fire, in his Century of Inventions; but he seems only to have availed himself of the expansive force, and not to have known the advantages arising from condensing the steam by an injection of cold water. This latter and most important improvement seems to have been made by Capt. Savery, some time prior to the year 1698, for in that year his patent for the use of that invention was confirmed by act of parliament. This gentleman appears to have been the first who reduced the machine to practice, and exhibited it in a useful form. This method consisted only in expelling the air from a vessel by steam, and condensing the steam by an injection of cold water, which making a vacuum, the pressure of the atmosphere forced the water to ascend into the steam-vessel through a pipe of 24 to 26 feet high, and by the admission of dense steam from the boiler, forcing the water in the steam-vessel to ascend to the height desired. This construction was defective, because it required very strong vessels to resist the force of the steam, and because an enormous quantity of steam was condensed by coming in contact with the cold water in the steam-vessel.

" About, or soon after that time, M. Papin attempted a steam-engine on similar principles, but rather more defective in its construction.

" The next improvement was made very soon afterwards by Messrs. Newcomen and Cawley, of Dartmouth: it consisted in employing for the steam-vessel a hollow cylinder, shut at bottom and open at top, furnished with a piston slid-

ing easily up and down in it, and made tight by oakum or hemp, and covered with water. This piston is suspended by chains from one end of a beam, moveable upon an axis in the middle of its length: to the other end of this beam are suspended the pump-rods.

"The danger of bursting the vessels was avoided in this machine; as, however high the water was to be raised, it was not necessary to increase the density of the steam, but only to enlarge the diameter of the cylinder.

"Another advantage was, that the cylinder, not being made so cold as in SAVERY's method, much less steam was lost in filling it after each condensation.

"The machine, however, still remained imperfect, for the cold water thrown into the cylinder acquired heat from the steam it condensed, and being in a vessel exhausted of air, it produced steam itself, which, in part, resisted the action of the atmosphere on the piston; were this remedied by throwing in more cold water, the destruction of steam in the next filling of the cylinder would be proportionally increased. It has, therefore, in practice, been found advisable not to load these engines with columns of water weighing more than seven pounds for each square inch of the area of the piston. The bulk of water, when converted into steam, remained unknown, until Mr. J. WATT, then of Glasgow, in 1764, determined it to be about 1800 times more rare than water. It soon occurred to Mr. WATT, that a perfect engine would be that in which no steam should be condensed in filling the cylinder, and in which the steam should be so perfectly cooled as to produce nearly a perfect vacuum.

"Mr. WATT having ascertained the degree of heat in which water boiled in vacuo, and under progressive degrees of pressure, and instructed by Dr. BLACK's discovery of latent heat, having calculated the quantity of cold water necessary to condense certain quantities of steam so far as to produce the exhaustion required, he made a communication from the cylinder to a cold vessel previously exhausted of air and water, into which the steam rushed, by its elasticity, and became immediately condensed. He then adapted a cover to the cylinder, and admitted steam above the piston to press it down instead of air, and instead of applying water, he used oil or grease to fill the pores of the oakum, and to lubricate the cylinder.

"He next applied a pump to extract the injection water, the condensed steam, and the air, from the condensing vessel, every stroke of the engine.

"To prevent the cooling of the cylinder by the contact of the external air, he surrounded it with a case containing steam, which he again protected by a covering of matters which conduct heat slowly.

"This construction presented an easy means of regulating the power of the engine, for the steam being the acting power, as the pipe which admits it from the boiler is more or less opened, a greater or smaller quantity can enter during the time of a stroke, and, consequently, the engine can act with exactly the necessary degree of energy.

"Mr. WATT gained a patent for his engine in 1768, but the further prosecution of his designs was delayed by other avocations till 1775, when, in conjunction with Mr. BOULTON, of Soho, near Birmingham, numerous experiments were made, on a large scale, by their united ingenuity, and great improvements added to the machinery, and an act of parliament obtained for the prolongation of their patent for twenty-five years: they have, since that time, drained many of the deep mines in Cornwall, which, but for the happy union of such genius, must immediately have ceased to work. One of these engines works a pump of eighteen inches diameter, and upwards of a hundred fathom, or 600 feet high, at the rate of ten or twelve strokes, of seven feet long each, in a minute, and that with one fifth part of the coals which a common engine would have taken to do the same work. The power of this engine may be easier comprehended, by saying, that it raised a weight equal to 81,000 pounds, eighty feet high, in a minute, which is equal to the combined action of two hundred good horses. In NEWCOMEN's engine this would have required a cylinder of the enormous diameter of 120 inches, or ten feet; but as in this engine of Mr. WATT and Mr. BOULTON the steam acts, and a vacuum is made, alternately above and below the piston, the power exerted is double to what the same cylinder would otherways produce, and is further augmented by an inequality in the length of the two ends of the lever.

"These gentlemen have also, by other contrivances, applied their engines to the turning of mills for almost every purpose, of which that great pile of machinery, the Albion Mill, is a well-known instance. Forges, slitting-mills, and other great works, are erected where nature has furnished no running water, and future times may boast that this grand and useful engine was invented and perfected in our own country."—*Botanic Garden*, Part i. p. 154. New-York edit.

Sounds in different Gases. p. 50.

That the different gases have different degrees of power in the propagation of sound, both with respect to intensity and tone, has been known since the year 1786, about which time Dr. PRIESTLEY, and Professor PEROLLE, of Turin, instituted a set of experiments on this subject, in which they substantially agreed. Since that time Professor JACQUIN, of Vienna, at the desire of Dr. CHLADNI, undertook a new course of experiments, with a view to the investigation of this subject. The results of these experiments are so different, and even contradictory, when compared with the former, that it is difficult to say on which side the truth lies.

OPTICS.

Achromatic Telescope. p. 54.

It appears that DOLLAND was not the first person who invented *Achromatic* glasses. As early as 1729, CHESTER MORE HALL, Esq. of *More-Hall,* in the county of Essex, in South-Britain, as appears by his papers, considering the different humours of the eye, imagined they were placed so as to correct the different refrangibility of light. He then conceived, that if he could find substances having such properties as he supposed these humours might possess, he should be enabled to construct an object glass that would show objects *colourless.* After many experiments, he had the good fortune to find these properties in two different kinds of glass; and by forming lenses made of such glass, and making them disperse the rays of light in contrary directions, he succeeded. About 1733 he completed several achromatic object glasses, (though he did not give them this name) that bore an aperture of more than two and an half inches, though the focal length did not exceed twenty inches. One of these glasses, which, in 1790, was in possession of the Rev. Mr. SMITH, of Charlotte-street, Rathbone Place, London, has been examined by several gentlemen of eminence in the scientific world, and found to possess the properties of the present Achromatic glasses.

In the trial at Westminster-Hall, about the patent for making Achromatic Telescopes, Mr. HALL was allowed to be

the inventor; but Lord MANSFIELD observed, "that it was not the person who locked up his invention in his scrutoire that ought to profit by a patent for such invention, but he who brought it forth for the benefit of the public."

That Mr. AYSCOUGH, optician, on Ludgate-Hill, was in possession of one of Mr. HALL's Achromatic Telescopes in 1754, is a fact indisputable.—*Gentleman's Magazine*, vol. lx. Part II. for 1790, p. 890, &c.

A new method of constructing *Achromatic Telescopes* was invented, a few years ago, by Professor BLAIR, of Edinburgh. This method consists in the use of one or more *fluid mediums*, of which the dispersive powers, being opposed to each other, not only correct the focal irregularities of the extreme rays of the Newtonian Spectrum, but likewise those near the middle; to which former opticians had little, if at all attended. From some unknown cause, however, this kind of achromatic telescope has not been much used. For a further account of it, see the *Transactions of the Royal Society of Edinburgh*, vol. iii.

Telegraph. p. 56.

Mr. JONATHAN GROUT, of Massachusetts, in 1799, invented a Telegraph on a plan which is said to be essentially different from any now in use in Europe. It has been for some time in operation between Boston and Martha's Vineyard, at which distance (90 miles) Mr. GROUT has asked a question and received an answer in less than ten minutes.

ASTRONOMY.

NEWTON. p. 58.

Among the honours of the eighteenth century, it ought to be considered as none of the least, that the immortal NEWTON lived the last 27 years of his life, and closed his glorious career in this age. The character of this stupendous Genius is too well known to require any details on the subject in this place; but as his name so frequently occurs in these volumes, and especially in the section on Astronomy, it may not be improper to compress into a few lines the following facts and dates concerning him.—He was born in Lincolnshire, in the

year 1642. He was educated at the University of Cambridge, where he graduated A. B. in 1664, and A. M. in 1668. He had made some of his greatest discoveries, and had laid the foundation of his *Principia* and his *Optics*, before he was 24 years of age. He was made Warden of the Mint in 1696, and Master of that institution in 1699, which office he held till his death, which took place in 1727, in the 85th year of his age. He received the honour of *knighthood* from Queen ANNE, in 1705.

New Planets. p. 63.

Since the close of the eighteenth century *two new Planets* have been discovered. The first was discovered January 1, 1801, by M. PIAZZI, of Palermo, in Sicily. It is called by the discoverer *Ceres*, but by his brother astronomers *Piazzi.* The second was discovered on the 28th of March, 1802, by M. OLBERS, of Bremen, and is called by him *Pallas*, but others attach to it the name of *Olbers.*

The Planet *Piazzi* (or *Ceres)* revolves between Mars and Jupiter. It is not, apparently, larger than a fixed star of the eighth magnitude. The inclination of its orbit to the plane of the ecliptic is about 10 deg. 36 min. 57 sec. and the time of its periodical revolution is four years, seven months, and ten days.

The Planet *Olbers* (or *Pallas)* also revolves in the wide space between Mars and Jupiter. It differs very little in appearance from stars of the eighth magnitude. The inclination of its orbit to the plane of the ecliptic is 35 deg. a very extraordinary degree of obliquity, which shows that the *Zodiac* must be considerably enlarged, if we continue to distinguish by that name the zone in the heavens in which all the planets perform their revolutions. The period of its revolution is four years, eight months, and three days.

The orbits of these two planets are nearer together than those of any others in our system. In its distance from the Sun *Piazzi* varies from 21 to 25, and *Olbers* from 27 to 28, taking the distance of the earth as the standard, and estimating it at 10.

In observing the phenomena, and in calculating the elements of these planets, besides the discoverers, HERSCHELL, DE LA LANDE, DELAMBRE, and BURCKHARDT, have par-

ticularly distinguished themselves.—Mr. HERSCHELL proposes to designate these celestial bodies, for the present, by the term "Asteroids."

Catalogues of Stars. p. 65.

Catalogues of Stars are of two kinds, either as collected into certain figures called *Constellations*, or according to their *right ascensions*, or, in other words, according to their order in passing over the meridian.

The first specimen of this latter kind of Catalogue, that is, according to the order of the right ascensions, was that published by DE LA CAILLE, in 1755. It contains the right ascensions and declinations of 307 stars, adapted to the beginning of the year 1750. In 1757 the same great astronomer published his *Astronomiæ Fundamenta*, containing a catalogue of the right ascensions and declinations of 398 stars. And in 1763, the year after his death, was published the *Cœlum Australe Stelliferum*, also by the same author, containing a catalogue of the places of 1942 stars.

In the *Nautical Almanack* for 1773 is given a catalogue of 387 stars, in right ascension, declination, longitude, and latitude, derived from the observations of the celebrated Dr. BRADLEY, Astronomer Royal of Great-Britain; adapted to the beginning of the year 1760.

In 1775 was published a catalogue, among the papers of the late TOBIAS MAYER, containing the right ascensions and declinations of 998 stars, which may be occulted by the Moon and Planets, adjusted to the year 1756.

At the end of the first volume of "Astronomical Observations made at the Royal Observatory at Greenwich," published in 1776, Dr MASKELYNE, the present Astronomer Royal, has given a catalogue of the places of 34 principal stars, in right ascension, and north polar distance; adapted to the beginning of the year 1770.

In 1782, M. BODE, of Berlin, published a very extensive catalogue of 5058 stars, collected from the observations of FLAMSTEAD, BRADLEY, HEVELIUS, MAYER, DE LA CAILLE, MESSIER, MONNIER, D'ARQUIER, and other astronomers; all adapted to the beginning of the year 1780, and accompanied with a celestial Atlas, or set of maps of the constellations, engraved in a most delicate and beautiful manner.

To these may be added Dr. HERSCHELL's catalogue of double stars, printed in the *Philosophical Transactions* for 1782 and 1783; MESSIER's *nebulæ* and clusters of stars, published in the *Connoissance des Temps* for 1784; and HERSCHELL's catalogue of the same kind, given in the *Philosophical Transactions* for 1786.

In 1792, Dr. ZACH, of Gotha, annexed to his *Tabulæ Motuum Solis* a new catalogue of the principal fixed stars, from his own observations, made in the years 1787, 1788, 1789, 1790. This catalogue contains the right ascensions and declinations of 381 principal stars; adapted to the beginning of the year 1800.

But all these catalogues yield, both in extent and value, to that of the DE LALANDES, whose diligence, skill, and perseverance, in this department of astronomical observation, do them the highest honour.—*Supplement to the Encyclopædia.*

HERSCHELL's *Construction of the Heavens, &c.* p. 66.

This celebrated Astronomer has given a very sublime and curious account of the *Construction of the Heavens*, with his discovery of some thousands of *nebulæ*, or clouds of stars; many of which are much larger collections of stars than all those put together which are visible to our naked eyes, added to those which form the galaxy, or milky zone which surrounds us. He observes, that in the vicinity of those clusters of stars there are proportionally fewer stars than in other parts of the heavens; and hence he concludes that they have attracted each other, on the supposition that infinite space was at first equally sprinkled with them. Mr. HERSCHELL thinks he has further shown, that the whole sidereal system is gradually moving round some centre, which may be an opaque mass of matter. See *Philos. Trans.* vol. lxxix.

Astronomical Records in Egypt. p. 68.

Professor TESTA, of Rome, has read to the Academy of Religion there, a memoir written by him, in which he proves, in the most evident manner, that the *Zodiacs*, lately discovered in Egypt, have not that antiquity which some pretend to give them, and, consequently, that they prove nothing against the chronology of MOSES. He asserts that the

Egyptians were not acquainted with the motion of the fixed stars in longitude, and that HIPPARCHUS was the first who discovered it. HIPPARCHUS, the astronomer here alluded to, was a native of Nicea, and flourished about the year 129 before JESUS CHRIST. Professor TESTA remarks also, that the Zodiac of Dindora is found in a temple of Grecian architecture, which bears the name of TIBERIUS; that this temple not being two thousand years old, the Zodiac discovered in it cannot have existed above four thousand; that in these Zodiacs is seen the sign of Libra, a constellation absolutely unknown to the ancient Egyptians. It appears, therefore, that a certain class of philosophers will not derive from the discovery of these Zodiacs that advantage which they expected.

Invention of the Quadrant by GODFREY. p. 71.

It is asserted, in the above-mentioned page, that the celebrated instrument called the *Quadrant*, which bears the name of Mr. HADLEY, and which is generally ascribed to him as the inventor, was really invented by Mr. THOMAS GODFREY, of Philadelphia. It will be proper, in this place, to give the reader some account of Mr. GODFREY, and of the evidence on which the above assertion was made.

The fullest and most satisfactory information on both these points, which the author has been able to obtain, is presented in the following letters, extracted from the *American Magazine*, for the months of July and August, 1758. Two of these letters are written by JAMES LOGAN, Esq. the distinguished classic scholar and botanist whose name has been mentioned in several parts of this work. For furnishing him with accurate copies of these documents, the author is indebted to his friend EBENEZER HAZARD, Esq. of Philadelphia, a gentleman who has been long distinguished for his researches in various departments of American history, and who has probably amassed a larger store of curious relics and facts relating to this extensive subject, than any other individual in the United States.

From the American Magazine for July, 1758, p. 475.

To the Proprietors, &c.

GENTLEMEN,

All civilized states have thought it their honour to have men of great ingenuity born or bred among them. Many

cities of ancient *Greece* had long and sharp contentions for the honour of HOMER's birth-place. And in later times volumes have been written in *Europe*, in disputing which city had the true claim to the invention of the art of printing. Nor is it to be wondered that mankind should be so generally eager in this respect, since nothing redounds more to the honour of any state than to have it said that some science of general utility to mankind was invented or improved by them. Nevertheless it often happens that the true author of many an useful invention, either by accident or fraud, loses the credit thereof, and, from age to age, it passes in the name of another. Thus it happened, heretofore, to COLUMBUS and many others; and thus also it has happened to a native of *Philadelphia*.

Mr. THOMAS GODFREY, it is well known to many of us here, was the real inventor of that very useful instrument called HADLEY's Quadrant or Octant. To him the merit is due, and to his posterity the profit ought to belong. This will fully appear from the three following genuine letters, which, I persuade myself, you will think worthy of being recorded in your Magazine, in order to restore, as far as possible, the credit of that invention to our city, and to the posterity of Mr. GODFREY. How he came to be deprived of it may be made a question by some. I answer that Mr. GODFREY sent the instrument to be tried at sea by an acquaintance of his, an ingenious navigator, in a voyage to *Jamaica*, who showed it to a Captain of a ship there just going for *England*, by which means it came to the knowledge of Mr. HADLEY, though, perhaps, without his being told the name of the real inventor. This fact is sufficiently known to many seamen and others yet alive in this city; and established beyond doubt by the following letters, written about that time. It is, therefore, submitted to the world, whether, after perusing the letters, they ought not, in justice, to call that instrument, for the future, GODFREY's, and not HADLEY's Quadrant.

To Dr. EDMUND HALLEY.*

ESTEEMED FRIEND,

The discovery of the Longitude having, of late years, employed the thoughts of many, and the world now expecting,

* An introductory paper, which I have not transcribed, not thinking it important, mentions this letter as No. 435 in the *Philosophical Transactions*, and entitled an "Account of Mr. THOMAS GODFREY's Improvement of DAVIS's Quadrant transferred to the Mariner's Bow." E. H.

from thy great sagacity and industry, some advances towards it, far exceeding all former attempts, from the motion of the moon, to the ascertaining of which thy labours have so long and happily been directed; the following notice, I hope, will neither be thought unseasonable, nor prove unacceptable. That the success of this method depends on finding the Moon's true place for one meridian by calculation, and for another by observation, I think is generally allowed; the first of which being depended on from thy great genius, what remains is some certain method for observation, practicable on that uncertain element, the sea. In order to this, thy predecessor at *Greenwich*, if I mistake not, for some years, published his calculations for the moon's future appulse to the fixed stars, which would save all observation, but that of a glass; but these not often happening, and the moon often having a considerable parallax when they did, that project dropt.

For finding her place by taking her greater distances from stars, the fore-staff or cross-staff cannot be exact enough: and Quadrants, Sextants, &c. with two Telescopes, are impracticable at sea.

Dr. BIESTER's late proposal for taking the difference of rad. ascension between the moon and a star, if that should prove practicable with sufficient exactness, would undoubtedly answer the intention of all that is to be expected from the moon, if her place were taken on or near the meridian. But to keep the arch of this instrument in the plane of the equator, and, at the same time, view two objects of unequal altitudes, and considerable distance from each other, by the edges of two sights, with the necessary accuracy, will not, perhaps, be so easy in practice as he would have it believed.

I shall, therefore, here presume, from thy favour shown me in England, in 1724, to communicate an invention that, whether it answer the end or not, will be allowed, I believe, to deserve thy regard. I have it thus:

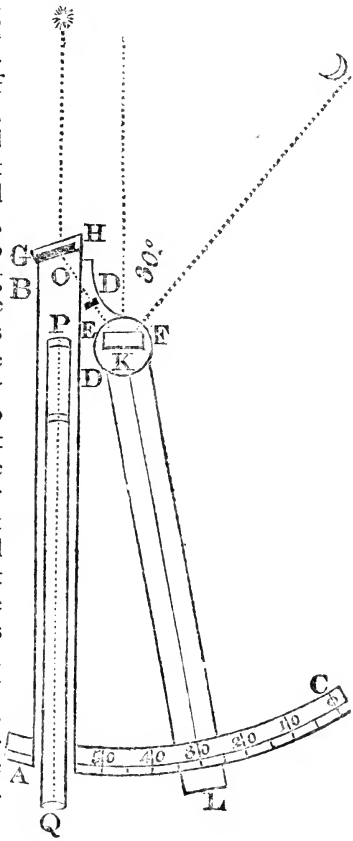
A young man, born in this country, THOMAS GODFREY by name, by trade a glazier, who had no other education than to learn to read and write, with a little common arithmetic, having, in his apprenticeship with a very poor man of that trade, accidentally met with a mathematical book, took such a fancy to the study, that, by the natural strength of his genius, without any instructor, he soon made himself master of that, and of every other of the kind he could borrow or procure in *English;* and finding there was more to be had in *Latin* books, under all imaginable discourage-

ments, applied himself to the study of that language, till he could pretty well understand an author on these subjects; after which, the first time I ever saw or heard of him, to my knowledge, he came to borrow Sir ISAAC NEWTON's *Principia* of me. Inquiring of him hereupon who he was, I was indeed astonished at his request; but after a little discourse, he soon became welcome to that or any other book I had. This young man, about eighteen months since, told me he had for some time been thinking of an instrument for taking the distances of stars by reflecting speculums, which he believed might be of service at sea; and not long after he showed me a common sea Quadrant, to which he had fitted two pieces of looking-glass in such a manner as brought two stars, at almost any distance, to coincide; the one by a direct, the other by a reflected ray, so that the eye could take them both together as joined in one, while a moving label or index on the graduated arch marked exactly half their distance: for I need not say that the variations of the angles of reflection from two speculums are double to the angle of the inclination of their planes, and therefore gives but half the angle or arch of the distance, which is the only inconveniency that appears to me to attend this. But as it may be made so simple, easy and light, as not to be much more unwieldy or unmanageable, though of a considerable length, than a single telescope of the same, that inconveniency will be abundantly compensated.

The description of it, as he proposes it, and has got one made, is nearly thus, which he is willing I should communicate to thee, if possibly it may be of service.

To a straight ruler or piece of wood, A B, of about three inches in breadth, and from 40 to 45 in length (or of any other that may be thought convenient), with a suitable thickness, an arch or limb, A C, of about 30 degrees to the radius, K L, is to be fixed. To the upper end of the piece A B, a piece, D D, is to be morticed, and in it the centre K taken, so that O P may be about six inches, and the angle K O P about 40 degrees. On this centre K, the ruler or index K L is to move, having a fiducial edge below answerable to the central point, to cut the graduations on the limb. On the upper end of this index a speculum of silvered glass, or rather metal, exactly plain, E F, of about three inches in length and two in height, is erected perpendicular to the plane of the index, and also nearly at right angles with its sides, the plane of the reflecting surface standing exactly over

the central point. At the end B, of the piece A B, another speculum of glass is to be in the same manner erected, which may be somewhat less than the other, with a square or oblong spot in it unsilvered, that a star, by a direct ray, may be seen through it; and the back of this speculum should be guarded with a thin brass plate, with an aperture in it equal to the unsilvered part of the glass; the edge of the aperture toward H to be exactly straight, dividing between the silvered and unsilvered part of the speculum, and standing in the line of the axis of the telescope. This speculum is to be set at an angle of about 20 deg. with the square of the piece A B, or at 110 deg. with the sides of it. Upon the piece A B, the telescope P Q is fixed, of a good aperture and field, with the axis placed as above. The limb is to be graduated by diagonals, or parallel circles, to half degrees and half minutes, beginning from C, which are to be numbered as whole ones. And if it be practicable to face wood with brass without warping, the whole face should be so covered; if not, then along the outward edge of the limb a narrow strip of brass plate may be let into the face of it, finely and equally indented on the edge, to take a screw fitted to that toothing to be fixed on the moving index at L, as your instruments are made that count by revolutions; and then, before this is used, it would be proper to take the distance of the two objects first nearly by a fore-staff, and from thence accordingly to set the index. This screw, at land, would be highly useful, but at sea it cannot be wrought, while the instrument is directed by the same



person, though, as the motions of the moon and variation of the angle is but slow, it may be brought to exactness by several trials in the intervals of direction. The instrument, as above described, will not take an angle of much above 50 degrees, which, for the purpose intended, may be fully sufficient. But if the speculum E F be made to take off and put on, and the end of the index at K be so notched as to turn that speculum from its first perpendicularity, to make an angle of about 25 degrees, it will then take any distance to 100 degrees.

By this description it may be thought that the utmost accuracy will be required in making the instrument: yet, of all that ever have been invented of so curious a kind, it will probably be found to demand the least; for, provided the speculums are good, on which the whole depends, if the first E F be set truly over the centre, the limb well graduated, and the other speculum be also set perpendicular, there can, I think, be no other error but what the instrument itself will easily rectify: for if it be directed to one star, and that be taken, at the same time, both by a direct ray through the glass G H, and by a reflection from E F, both exactly coinciding at O, it is evident that then the speculums are exactly parallel. And if this falls not precisely when the index cuts 0 degrees, if the variation be noted, this constantly added or subtracted, according as it falls, will fully rectify all other errors. So in fixing the speculum E F to another angle, as has been proposed, the like method may or must be taken, viz. to observe two stars at the distance of about 45 or 50 degrees, by the speculum, in its first situation, and then the same stars by it again in its second, and the difference of the intervention of the index on the limb being noted, and constantly added to the arches taken in the second situation, will give the true distance. This method of observing one and the same star, in the first manner, or two stars in the second, as has been mentioned, will also rectify errors even in the speculums: for the line of the ray K O is in all cases constantly the same; and, upon the whole, I may safely say the instrument will be found much more certain in practice than at first it may appear in theory, even to some good judges. But I am now sensible I have trespassed in being so particular when writing to Dr. HALLEY; for I well know that, to a gentleman noted for his excellent talent of reading, apprehending, and greatly improving, less would have been sufficient; but as this possibly may be communicated by thee, I shall crave leave fur-

ther to add, that the use of the instrument is very easy. For if the index be set so near the distance of the moon and stars, and the limb so held as to cut the body of the moon, upon directing the telescope to the star, her image will, of course, be reflected on some part of the speculum G H. There is no absolute necessity the star and moon should coincide exactly at the line limiting the silvered and unsilvered part of the latter speculum; for the transparent part of that glass will often reflect the moon's image sufficiently for the telescope to take it, and if her limb in that and the star exactly coincide near it, it may be sufficient, though the nearer to that line the better. Now their distance being found, the tables that give the moon's place may be depended on for her diameter and her latitude, which last being known, there are three sides of a triangle given to find the angle at the pole of the ecliptic, which, compared with the star's longitude, determines her place for that instant: for, in respect to her latitude when she is swiftest in motion, when nearest her nodes, and when the inclination of the orbs is greatest (if these could all happen together), yet the variation of her latitude, in the space of one hour, equal to 15 deg. of longitude on the earth, if a star be taken somewhat near the ecliptic, and not very near the moon, will not alter the angle at the pole but a very few seconds. The nearness of the speculum G H is no disadvantage, because the rays come reflected in the same manner as they come direct. It may be needless to add that, when practicable, the moon should be taken when near the meridian—or that the instrument will equally take the distance of the sun from the moon, when visible, as she often is, in the day-time; for which purpose there must be a place made at M for a darkening glass, to be fixed there when necessary, and the telescope directed to the moon. Nor need I add, that the same instrument will very well serve for taking the distance of any two stars, a comet, &c. always taking the brightest by reflection; all which is obvious. But I must further observe, with pleasure, that if we do not quite mistake in all that has been said here, there is now a method found by it to obtain what is equivalent to a bodily appulse of the moon to a fixed star, or to the sun at any moment when visible, which, indeed, might be wished; but if the longitude could ever be expected to be determined by the motions of the moon (to which end J. FLAMSTEAD's, and thy more assiduous labours in observing her, have, I suppose, been principally levelled), and this instrument be duly made

to answer what is proposed, as it may be framed light and easily manageable, thou wilt then, with thy accurate tables, have obtained the great desideratum, and all that can in this way be had from our satellites. And if the method of discovering the longitude by the moon is to meet with a reward, and this instrument, which, for all that I have ever read or heard of, is an invention altogether new, be made use of, in that case I would recommend the inventor to thy justice and notice. He now gets his own and family's bread (for he is married) by the labour of his own hands only, by that mean trade. He had begun to make tables of the moon, on the very same principles with thine, till I lately put a copy of those that have lain so many years printed, but not published; with W. INNY's, into his hands, and then, highly approving them, he desisted. We both wish very much to see thy tables completed, and ushered into the world by thy own hand. On the receipt of this I shall hope for a line, with thy thoughts on it, which, however they prove, will afford a pleasure to

Thy friend,

J. LOGAN.

Pennsylvania, May 25, 1732.

From the American Magazine for August, 1758, p. 528.

To the Royal Society.

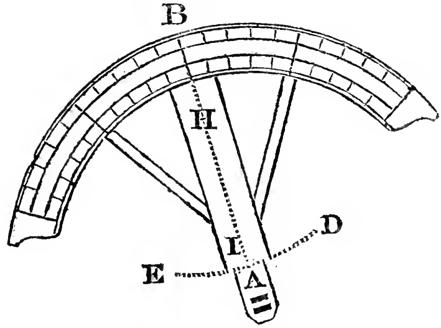
GENTLEMEN,

As none are better able than the *Royal Society* to prove and judge whether such inventions as are proposed for the advancing useful knowledge will answer the pretensions of the *inventors* or not; and as I have been made acquainted, though at so great a distance, of the candour of your learned society in giving encouragement to such as merit approbation, I have, therefore, presumed to lay before the society the following, craving pardon for my boldness.

Finding by what difficulty a tolerable observation of the sun is taken by DAVIS's Quadrant, and that in using it, unless the spot or shade be brought truly in the line of the horizon-vane, the observation, when made, is good for nothing; to do which requires much practice, and, at best, is but catching an observation; and considering further the smallness of the 60 deg. arch, and the aptness of wood to cast, which makes often little better than guess-work; I *therefore*

applied my thoughts, upwards of two years, to find a more certain instrument, and contrived the following improvement, as I think, in the make and use of the bow; viz.

The quadrant is to be numbered from each end to 90 at the other, as in the figure. The sight and glass vanes are the same with the common, excepting that the glass should be larger, and I think it would be better if ground to the segment of the cylinder. The horizon-vane should be like that in the figure thereof; having three holes, I K L; one hole, I, to fit on the centre of the Quadrant, A; the other two, K L, to see the horizon through, whose length across the vane may be one-eighth of the radius A B, or more; the horizon-vane should be a little hollowed, answerable to the curvature of the circle D A E, or cylinder, whose semi-diameter A H is about seven-elevenths of A B, the radius of the quadrant.



In observing with this Quadrant at sea, let the sight and glass vanes be kept nearly on the same numbers, or at equal distances from the ends of the arch, and then it will be sufficiently exact to bring the spot and horizon in a right line, or any part of the horizon-vane, by moving the vanes nearer together or further apart, the middle of the horizon-vane being parallel to the horizon, then the zenith distance will be the sum of the distances of the vanes from the end of the Quadrant arch. For, putting r=the radius of the Quadrant, a=the distance of the spot from the middle of the horizon-vane, s=the sine, and c=the cosine of half the sun's altitude, unity being radius, the sine of the error will be nearly equal to $c\,\frac{11}{14}\times\frac{2saa}{rr}$; and, therefore, when greatest (which is when the zenith distance is 00.00, or 47 deg. 45 min.), of the distance of $\frac{1}{16}$ of the radius of the Quadrant from the middle of the horizon-vane, it is but 1.30; I would advise to bring

the upper or lower edge of the spot, and not the middle and horizon, on a right line, and then subtract or add sixteen minutes for the sun's semi-diameter from or to the zenith distance given by the vane.

N. B. There should be an allowance for the observer's height above the surface of the sea, by subtracting four, five, or six minutes. A table of this kind would not be amiss on the back of the Quadrant.

There may be some graduations put on the staff, near the centre, to be cut by a plumb-line hung, or a pin put into a small hole for land observations. One of these Quadrants, between eighteen inches and two feet radius, if well graduated, will be sufficient to take the sun's zenith distance within two or three minutes.

Succeeding so well with the sun, encouraged me to take what appeared a more difficult task, the finding some way to take the altitude of the stars at sea (when the horizon may be seen) better than by the fore-staff, which I concluded must be by bringing the two objects, horizon and star, together. I first considered one reflection; but the faults of DAVIS's Quadrant were here enlarged, which is chiefly the flying of the objects from each other, by the least motion of the instrument. I then examined what two reflections would do, which perfectly answered my desire, being equally useful in taking the distance of stars from each other, and also from the moon, and I believe practicable at sea; for I found that when one star was made to coincide by two reflections with another, the distance of these stars would be double the inclination of the reflecting planes, as may be easily demonstrated.

I see but one fault in this instrument, and that is, that three feet radius in this has a graduation no larger than a Quadrant of eighteen inches radius. I hope Dr. HALLEY has received a more full account of this from J. LOGAN, Esq. therefore I shall add no more than that I am, gentlemen,

Yours, &c. T. GODFREY.

Philadelphia, Nov. 9, 1734.

Page 529. *Extracts from "A further Account of* THOMAS GODFREY's *Improvement of* DAVIS's *Quadrant transferred to the Mariner's Bow."*

Being informed that this improvement, proposed by THOMAS GODFREY, of this place, for observing the sun's altitude at sea with more ease and expedition than is practicable

by the common instrument in use for that purpose, was last winter laid before the Royal Society, in his own description of it, and that some gentlemen wished to see the benefit intended by it more fully and clearly explained, I, who have here the opportunity of knowing the author's thoughts on such subjects, being persuaded, in my judgment, that if the instrument, as he proposes it, be brought into practice, it will, in many cases, be of great service to navigation, have, therefore, thought it proper to draw up a more full account of it than the author himself has given, with the advantages attending it, which, if approved of by better judgments, to whom what I offer is entirely submitted, it is hoped the use of it will be recommended and further encouraged, as well as the author. The use of the improvement, with its conveniences, as also a description of it, are as follows.

[Then follows a repetition of the account of GODFREY's having studied—what occurred to him about the importance of knowing the latitude and longitude of a ship's place, &c. which I do not transcribe, as it is lengthy, and not to your purpose. E. H.]

Page 532.—Some masters of vessels who sail from hence to the *West-Indies* have got some of them* made, as well as they can be done here, and have found so great an advantage in the facility and in the ready use of them in those southerly latitudes, that they reject all others. And it can scarce be doubted, but when the instrument becomes generally known, it may, upon the Royal Society's approbation, if the thing appears worthy of it, more universally obtain in practice. It is now four years since THOMAS GODFREY hit on this improvement: for his account of it, laid before the Society last winter, in which he mentioned two years, was wrote in 1732; and in the same year, 1730, after he was satisfied in this,† he applied himself to think of the other, viz. the reflecting instrument by speculums for a help in the case of longitude, though it is also useful in taking altitudes; and one of these, as has been abundantly proved by the maker, and those who had it with them, was taken to sea, and there used in observing the latitude the winter of that year, and brought back again to *Philadelphia* before the end

* GODFREY's instruments.

† That is, I suppose, being "satisfied," that he had made a real *improvement* in the Quadrant E. H.

of February, 1731, and was in my keeping some months immediately after.

*It was indeed unhappy, that, having it in my power, seeing he had no acquaintance nor knowledge of persons in *England*, that I transmitted not an account of it sooner. But I had other affairs of more importance to me; and it was owing to an accident which gave me some uneasiness, viz. his attempting to publish some account of it in print here, that I transmitted it at last, in May, 1732, to Dr. HALLEY, to whom I made no doubt but the invention would appear entirely new; and I must own I could not but wonder that our good will at least was never acknowledged. This, on my part, was all the merit I had to claim, nor did I then, or now, assume any other in either of these instruments. I only wish that the ingenious inventor himself might, by some means, be taken notice of, in a manner that might be of real advantage to him.

There needs not, I suppose, much more of a description of the instrument than has been given. I shall only say that the bow had best be an arch of about 100 deg. well graduated and numbered both ways; the radius 20 or 24 inches; the curve at the centre to be one-twentieth of the radius on each side, that is, one-tenth of it in the whole; the radius of that curve $\frac{64}{100}$ parts of the radius of the instrument; that the glass for the solar vane should not be less, but rather larger than a silver shilling, with its vertex very exactly set; and that the utmost care be taken to place the middle of the curve exactly perpendicular to the line or radius of 45 deg. as the observer must also take care that the two vanes on the limb be kept nearly equidistant from that degree. To which I shall only add, that it may be best to give the horizontal vane only one aperture, not two. The rest, I suppose, may be left to the workman. Thus, doubting I have already been too prolix on the subject, to which nothing but a sincere inclination to promote any thing that might contribute to a public benefit, and to do some justice to merit, could induce me, I shall only request that what I have here offered may be construed by that intention.

J. LOGAN.

Philadelphia, June 28, 1734.

* All these circumstances of Mr. LOGAN's complaint, and almost every thing that follows to the end, except the directions for making the instrument, are left out of the account published in the *Philosophical Transactions*, which strengthens the conjecture that justice has not been done to the original inventor.

P. S. [*By the Editors of the Magazine.*] It is easy to see, by a careful perusal of these two letters, and that in our last Magazine, the progress of this invention, and how far Mr. GODFREY ought to be considered as the inventor. It is our business to give impartial accounts of facts and transcripts of authentic papers. The reader, after that, is to judge for himself. For our own part, we have no hesitation in pronouncing Mr. GODFREY the real original inventor of this famous and useful instrument.

The following extract of a letter from Mr. HAZARD, which accompanied the above documents, ought to be added, in justice both to the Royal Society and to Mr. GODFREY.

"Alderman HILLEGAS, of this city, (Philadelphia) knew GODFREY. He says he remembers to have heard, perhaps 50 years ago, that, as HADLEY had obtained the patent, complete justice could not be done to GODFREY; but that the Royal Society, thinking his ingenuity ought to be rewarded, either subscribed for him as individuals, or gave him out of their funds, £200 sterling: and knowing his infirmity (for it seems he was apt to indulge in intemperate drinking), they thought it better to send the amount in household furniture than in cash, and, *inter alia*, sent him a *clock*, which the Alderman remembers to have seen."

GODFREY had a son, THOMAS GODFREY, jun. who, in 1765, published a volume of *Juvenile Poems.* The young man is spoken of, by the writer of the preface, as possessing great natural endowments, with but little cultivation; and as deserving to be ranked, as well as his father, among the *curiosities* of Pennsylvania.—*MS. Letter of the Rev. Dr.* ELIOT, *of Boston, to the Author.*

It is worthy of notice, that the use of the *Quadrant* in question was confined to the English nation until the year 1736, when M. D'APRES DE MANNEVILLETTE, the great maritime Geographer, employed it on board a French ship; and on his return to France, one of the earliest objects of his attention was to state, in a public print, his high estimation of this curious instrument. He thus had the honour of introducing to his countrymen one of the most valuable inventions of the age.

NOTES ON CHAPTER II.

STAHL. p. 79.

GEORGE ERNEST STAHL was born in Franconia, in 1660, and died in 1734, in the 75th year of his age. He was undoubtedly a man of great talents and learning, and the author of many valuable works; the most important of which relate to his systems of *Medicine* and of *Chemistry*. He published an edition of the *Physica Subterranea* of BECHER, after the death of that great Chemist, and adopted the theory which this work displayed; but he simplified and improved it so much, that he made it entirely his own; and accordingly it has been ever since known by the name of the *Stahlian* theory.

Latent Heat. p. 81.

The doctrine of *Latent Heat* was first taught by Dr. BLACK, of the University of Edinburgh, in the year 1757. His discovery, and the doctrine which he founded on this discovery, may be considered as comprized in the following propositions. Whenever a *solid* is converted into a *fluid*, it combines with a certain portion of caloric, without any augmentation of its temperature, and it is this portion of caloric which occasions the change. When this fluid is re-converted into a solid, the caloric which produced the fluidity leaves it without any diminution of its temperature; and it is this abstraction which occasions the change. Thus the combination of a certain portion of caloric with *ice* causes it to become *water*, and the abstraction of a certain portion of caloric from water causes it to become ice. Water, then, is a compound of ice and caloric; and, in general, all fluids are combinations of the solid to which they may be converted by cold, and a certain portion of caloric. The same principle, according to this philosopher, applies to the conversion of *liquids* into *elastic fluids*, or the reverse; this conversion and re-conversion depending on the addition or abstraction of caloric. To this caloric Dr. BLACK gave the name of *latent heat*, because its presence is not indicated by the thermometer.

The great importance of this discovery, and the extensive application which has been since made of it, in explaining *fluidity*, *congelation*, *evaporation*, *animal heat*, and many other phenomena, render the period of its annunciation to the world one of the most interesting æras in the history of chemical science.

Fixed Air, or Carbonic Acid Gas. p. 81.

The numerous and important relations of this chemical compound render its original discovery, and the subsequent additions to our knowledge of it, worthy of particular notice in detailing the progress of the last age in this branch of science.

PARACELSUS and VAN HELMONT were acquainted with the fact, that air is extricated from solid bodies during certain processes, and the latter gave to air thus produced the name of *gas*, by which word he meant to express every thing which is driven off from bodies in the state of vapour by heat. BOYLE called these kinds of air *artificial airs*, and suspected that they might be different from the air of the atmosphere. HALES ascertained the quantity of air that could be extricated from a great variety of bodies, and showed that it formed an essential part of their composition. Dr. BLACK proved that the substances called *lime*, *magnesia*, and *alkalies*, are compounds, consisting of a *peculiar species of air*, and pure lime, magnesia, and alkali. To this species of air he gave the name of *fixed air*, because it existed in these bodies in a fixed state, though he knew not the materials of which it is composed. This air or gas was afterwards investigated by Dr. PRIESTLEY, and a great number of its properties ascertained. From these properties Mr. KEIR first concluded that it was an *acid;* and this opinion was soon confirmed by the experiments of BERGMAN, FONTANA, and others. Dr. PRIESTLEY at first suspected that this acid entered as an element into the composition of atmospherical air; and BERGMAN, adopting the same opinion, gave it the name of *aërial acid*. Mr. BEWLY called it *mephitic acid*, because it could not be respired without occasioning death. Mr. KEIR called it *calcareous acid;* and, at last, M. LAVOISIER, after discovering that it is formed by the combination of *carbon* and *oxygen*, gave it the name of *carbonic acid gas*, which it now generally bears.—THOMPSON'*s Chemistry*.

Inflammable, or Hydrogenous Air. p. 82.

This air was obtained by Dr. MAYOW, and afterwards by Dr. HALES, from various substances, and had been known, long before, in mines, under the name of the *fire damp.* But Mr. CAVENDISH ought to be considered as its real discoverer; since it was he who, about the year 1766, first examined it, pointed out the difference between it and atmospheric air, and ascertained the greatest number of its properties. It was found by M. LAVOISIER to be twelve times lighter than common air. Its non-respirable character was more fully determined by SCHEELE, FONTANA, and DAVY. The products resulting from the combination of hydrogen with the *sulphuric*, *phosphoric*, and *carbonic* acids, were discovered and investigated principally by SCHEELE, BERGMAN, FOURCROY, VAUQUELIN, GENGEMBRE, KIRWAN, and VOLTA. It was first called *Hydrogen* by the French Academicians, because it enters into the composition of water.

Composition of Water. p. 82.

Water was believed, by the ancients, to be one of the four elements of which every other body is composed. The opinion that it is a simple substance seems generally to have prevailed until the year 1781, when Mr. HENRY CAVENDISH, of Great-Britain, discovered, by several experiments, that it is a compound, and formed by the union of oxygen and hydrogen. In a few months afterwards, the conclusion of Mr. CAVENDISH was confirmed by the experiments of M. LAVOISIER, and others: insomuch that, during the last fifteen or twenty years, the composition of water has been generally considered as one of the best established facts in chemistry. It has been *decomposed* and *recomposed*, and found to consist of 85 parts, by weight, of oxygen, and 15 of hydrogen.

This discovery soon began to change the principles of chemical science. By furnishing a satisfactory explanation of many phenomena which were formerly difficult of explanation, if not wholly inexplicable, it has, perhaps, contributed more than any other single discovery to promote the progress of this branch of philosophy.

Bergman. p. 82.

Sir Torbern Bergman was a native of Sweden, where he was born in the year 1735. He is, beyond all doubt, entitled to a place among the greatest men of his age. He was highly distinguished as a chemist, mineralogist, geometrician, and astronomer. In the two first mentioned branches of science he was particularly eminent. In the history of chemistry few names occur more frequently, or are associated with more important services, than his. He died in the year 1784.

Scheele. p. 82.

Charles William Scheele was born Dec. 19, 1742. He was bound an apprentice, when very young, to an Apothecary at Gottenburgh, where he first felt the impulse of that genius which afterwards made him so conspicuous. He durst not, indeed, devote himself openly to chemical experiments; but he contrived to make himself master of the science by devoting those hours to study which were assigned to him for sleep. He afterwards went to Sweden, and settled as an apothecary at Köping. Here Bergman first found him, saw his merit, and encouraged it, adopted his opinions, defended him with zeal, and took upon himself the charge of publishing his treatises. Encouraged and excited by this magnanimous patronage, the genius of Scheele, though unassisted by education or wealth, burst forth with astonishing lustre. To wonderful acuteness, ardour, and persevering diligence in his philosophical investigations, he added singular purity and amiableness of moral and social character. His outward appearance, however, was by no means expressive of that great mind which lay concealed, as it were, under a veil. He died in 1786, in the 44th year of his age.—Thompson's *Chemistry*.

Azote. p. 82.

This gas was discovered, in 1772, by Dr. Rutherford, now Professor of Botany in the University of Edinburgh, and an account of it published in his thesis *De Aere Mephitico*,

in the same year. M. LAVOISIER, in 1775, made known this gas as a component part of atmospheric air. About the same time it was procured by SCHEELE, and proved to be a distinct fluid. Its specific gravity has been investigated and determined by KIRWAN and LAVOISIER, the latter of whom makes it 0.00115, or to common air as 942.6 to 1000. The *combustibility* of azotic gas, and the production of *nitric acid* by this process, were first discovered by Mr. CAVENDISH, and communicated to the Royal Society in 1785. The name *Azote* was given to this gas by the French Academicians, and is derived from its incapacity to support life.

Oxygen. p. 83.

The gas, the base of which is commonly known by this denomination, was discovered by Dr. PRIESTLEY, on the 1st of August, 1774, and called by him *dephlogisticated air*. Mr. SCHEELE, of Sweden, discovered it in 1775, without any previous knowledge of what Dr. PRIESTLEY had done; and gave it the name of *empyreal air*. CONDORCET gave it first the name of *vital air*, and M. LAVOISIER afterwards gave it the name of *oxygen gas*, which is now generally adopted.

The discovery of this substance, and the investigation of its properties, deserve to be ranked among the most important events recorded in the history of chemistry. The explanation which they have afforded to the principles of *combustion, respiration, acidity*, &c. place their value in a most interesting point of light. To this discovery, and these investigations, we may trace the commencement of that grand revolution in chemical science, which was triumphantly confirmed by the discovery of the *composition of water* in 1781, though not presented to the world in a complete and systematic form until 1787.

PARACELSUS believed that there was only one acid principle in nature, which communicated taste and solubility to the bodies in which it was combined. BECHER embraced the same opinion, and added to it, that this acid principle was a compound of *earth* and *water*, which he considered as two elements. STAHL adopted the theory of BECHER, and endeavoured to prove that the acid principle is *sulphuric acid*, of which, according to him, all the other acids are mere compounds; but his proofs were only conjectures or vague experiments, from which nothing could be deduced. Never-

theless, his opinion, like every other which he advanced in chemistry, continued to have supporters for a long time, and was even mentioned by Macquer. At last its defects began to be perceived. Bergman and Scheele declared openly against it; and their discoveries, together with those of Lavoisier, demonstrated the falsehood of both parts of the theory, by showing that sulphuric acid does not exist in the other acids, and that it is not composed of water and earth, but of sulphur and oxygen.

"The opinion, however, that acidity is owing to some principle common to all the salts, was not abandoned. Wallerius, Meyer and Sage had advanced different theories in succession about the nature of this principle; but as they were formed rather on conjecture and analogy than direct proof, they obtained but a few advocates. At last M. Lavoisier, in 1778, by a number of ingenious and accurate experiments, proved that several combustible substances, when united with oxygen, form acids; that a great number of acids contain oxygen; and that, when this principle is separated from them, they lose their acid properties. He concluded, therefore, that oxygen is the *acidifying principle*, as the word imports, and that acids are nothing else but combustible substances combined with oxygen, and differing from one another according to the nature of the combustible base."—See Thompson's *Chemistry*.

This doctrine, with few exceptions, has been confirmed by subsequent experiments, and is now generally received among chemists.

New Acids. p. 83.

The Acids known at the close of the eighteenth century amount to about *thirty*, the greater part of which have been discovered within the last *forty years*. Of these nearly one third were discovered by the celebrated Scheele, and the remainder chiefly by Margraaf, Priestley, Lavoisier, Vauquelin, Berthollet, and Kier.

Composition of the Atmosphere. p. 83.

For our knowledge of the component parts of atmospheric air, we are indebted to the successive experiments and disco-

veries of several philosophers. The first step was made by Dr. PRIESTLEY, in 1774, by the discovery of oxygen gas. This gas, according to the prevailing theory of the time, he considered as air totally deprived of phlogiston. Azotic gas, on the other hand, was air saturated with phlogiston. Hence he considered common air as oxygen gas combined with an indefinite portion of phlogiston, and varying in purity according to that portion, being always pure in an inverse proportion to the quantity of phlogiston it contained.

While Dr. PRIESTLEY was making experiments on oxygen gas, SCHEELE, of Sweden, proceeded to the analysis of air in a different manner. From his experiments he concluded that common air is compounded of two different elastic fluids, viz. *foul air*, which constitutes more than two thirds of the whole, and *another air*, which is alone capable of supporting flame and animal life, and to which he gave the name of *empyreal air*. The *foul air* of SCHEELE was the same with the *phlogisticated air* of PRIESTLEY; and the *empyreal air* of the former was the same with the *dephlogisticated air* of the latter, or with what is at present called *oxygen gas*.

While SCHEELE was occupied with these experiments, LAVOISIER was assiduously employed on the same subject, and was led, by a different road, to precisely the same conclusions. He found that air is composed of azotic and oxygen gases; and, from a variety of experiments, he determined the proportions to be 73 parts of azotic gas, and 27 parts of oxygen gas. These experiments were made in the year 1776.

Secretion of Oxygen by Vegetables. p. 83.

Dr. PRIESTLEY concluded from his experiments, and it has been since generally believed by INGENHOUZ, SENNEBIER, and other vegetable physiologists, that vegetables, in the course of their germination and growth, when exposed to solar light, absorb azote and emit oxygen, and thus purify the surrounding air. But, by a series of ingenious experiments lately published, Professor WOODHOUSE, of Philadelphia, has drawn into question the truth of these conclusions. From the result of these experiments, he contends that the germination of seeds and the growth of plants do not purify atmospherical air; but that, whenever they appear to afford oxygen gas, it is by devouring the coal of carbonic acid gas for food, and leaving its oxygen in the form of pure air. He has

also made experiments on the effects produced by the leaves of plants in common air, impregnated with carbonic acid gas, and exposed to solar light; in which cases the carbonic acid disappeared, and the oxygenous gas increased. And from trials made with the fresh leaves of many different plants, exposed to sunshine in pump-water, river-water, and this latter charged with carbonic acid, he is confirmed in the same conclusion. Dr. WOODHOUSE, therefore, denies that vegetables either decompose water, emit oxygen, or absorb azote, as has been some time commonly believed.—NICHOLSON'S *Philos. Journal,* vol. ii. for July, 1802.

Respiration. p. 83.

Closely connected with the discovery of *oxygen,* and of the composition of *atmospheric air,* stand the principles of *respiration* which have been received for a few years past. This function was little understood thirty years ago; and to the modern improvements in chemistry, physiologists are indebted for all the rational doctrines with respect to it which are now taught. The most distinguished chemists who have thrown light on this subject, are PRIESTLEY, LAVOISIER, FOURCROY, BLACK, CRAWFORD, LA GRANGE, BEDDOES, WATT, and DAVY. By means of the experiments of these philosophers it has been discovered, that respiration produces and supports *animal heat;* contributes to the *formation of blood;* and imparts a stimulating power to this fluid, which is necessary to produce the alternate *contractions* of the heart.

LAVOISIER. p. 87.

The important services of this great philosopher in forming the theory of the French academicians, and the intrinsic worth of his character, render it proper that some account should be given of him in this place.

ANTOINE LAURENT LAVOISIER was born at Paris, in the year 1743. He early discovered a taste for the study of the physical sciences, and, for a considerable time, directed his attention to most of them in succession, without discovering a preponderating inclination for any one in particular. This continued to be the case till about the year 1770, when

the important discoveries in chemistry, by BLACK, PRIESTLEY, SCHEELE, and CAVENDISH, fired his ambition, and directed his attention more particularly to chemical philosophy, to which he almost exclusively attached himself during the remainder of his life.

It is generally known, that his experiments and discoveries were among the principal means of establishing that revolution in the *theory* and *nomenclature* of chemical science, which has been, with great propriety, denominated the *Lavoisierian* theory. After numerous publications on different departments of chemistry, in the *Memoirs* of the *Academy of Sciences*, and other scientific Journals, in which he successively treated of *combustion*; the analysis of *atmospheric air*; the formation and fixation of *elastic fluids*; the properties of *heat*; the composition of *acids*; the decomposition and recomposition of *water*; the dissolution of *metals*, *vegetation*, &c. &c. he at length combined his philosophical views into a consistent body, which he published in 1789, under the title of *Elements of Chemistry*; a work which has been pronounced one of the most elegant models of philosophical arrangement, and of clear logical composition, that was ever presented to the world.

He continued after this to pursue his favourite study with unabated diligence: his wealth enabled him to make experiments on a great scale; his ardour, acuteness, and extended views, enabled him to avail himself of every advantage; and he continued to instruct his countrymen and the world, by the developement of new truth, or the recommendation of useful economical improvements, until the month of May, 1794, when he became an object of the malignant phrenzy of Robespierre, and suffered under the guillotine, in the fifty-first year of his age.

Heat. p. 92.

Few questions in science have given rise to more discussion than that which relates to the *nature of heat*. Whether it be a distinct *substance*, or a mere *quality* of substance, has long been the subject of disputation. By the ancient philosophers, heat seems to have been considered as a peculiar subtle fluid or element; and this opinion appears to have prevailed until the time of Lord BACON. That philosopher was the first, it is believed, who advanced the hypothesis, that heat is a qua-

lity of matter, and depends on a peculiar vibration of its particles. This opinion was afterwards adopted by BOYLE and NEWTON, whose authority rendered it considerably popular; the ancient opinión, however, was still held by many. BOERHAAVE, at an early period of the eighteenth century, entered the lists against NEWTON on this subject, and maintained, with great force of argument, that heat is a *distinct substance*. From the time of BOERHAAVE, till towards the close of the century under review, this doctrine was almost universally received. STAHL, MACQUER, BLACK, PRIESTLEY, SCHEELE, BERGMAN, LAVOISIER, CRAWFORD, IRVINE, KIRWAN, PICTET, DE LA PLACE, and most other distinguished chemists, though differing as to some details of opinion on this subject, all agreed in considering heat as a distinct positive substance.

But, towards the close of the century, the doctrine of BACON was revived by Count RUMFORD and Mr. DAVY. These philosophers, observing that caloric continues to be extricated from a body subjected to friction, so long as the friction is kept up, and the texture or form of the body is not destroyed, and that this heat-yielding process goes on to an *indefinite* extent, concluded that this phenomenon is inexplicable on the supposition of heat being matter; and that those effects which have been referred to the operation of a peculiar calorific matter, depend entirely on a *vibratory motion* of the particles of bodies; and that from the generation, communication, or abstraction of this motion, all the phenomena abscribed to caloric are to be explained.—See RUMFORD's *Essays*, vol. ii. and *Contributions to Medical and Physical Knowledge*.

This doctrine, however, has but few advocates. The suffrages of modern philosophers are almost unanimous in favour of the opinion, that caloric or heat is a distinct fluid. The latter opinion, indeed, seems to be confirmed to a degree little short of demonstration, by the late experiments of Dr. HERSCHELL on this subject, who has shown, that the rays of *light*, and the rays of *heat* emitted from the sun, are distinct and separable; that the latter, as well as the former, are *refracted* by transparent bodies, and *reflected* by polished surfaces; and that both consist of particles which mutually repel each other, and which produce no sensible effect upon the weight of other bodies.—See the *Philosophical Transactions* for 1800.

It cannot be denied, indeed, that some difficulties attend the doctrine of heat, being a distinct and positive substance. Nor is that by any means one of the smallest which Count RUM-

FORD suggests, viz. "that any thing which any insulated body, or system of bodies, can continue to furnish, *without limitation*, cannot be a material substance." Yet the *electric fluid* is granted, on all hands, to be a distinct substance; and we know, that this fluid is constantly furnished, *without limitation*, by means of friction. On the whole, the old opinion seems still, with all its difficulties, to stand on firmer ground than any other, and to have by far the greatest number of advocates.

The doctrine of *radient heat*, or that heat resembles light in being propagated in *rays*, or right lines, was, in some measure, known to MARIOTTE, LAMBERT, and SCHEELE, but was more clearly established afterwards by the experiments of SAUSSURE, PICTET, and Count RUMFORD; and, finally, the laws of this propagation were more fully developed and laid down by Dr. HERSCHELL, in his celebrated experiments on light and heat before mentioned.

Count RUMFORD concluded, from his experiments, that fluids do not *conduct* heat; but he ascribes to them what he denominates a *carrying* power: in other words, he supposes, that in heating fluids, each particle must come in succession to the source of heat, and receive its portion, but that among the particles themselves all *interchange* and communication of heat is impossible. The experiments by which he considers himself as having established this point are certainly striking, and their results highly curious; but the justness of his conclusions has been called in question, and philosophers do not seem to view his decision as absolute and final. Further experiments must decide the controversy.

"Dr. M'CLURG, of our city (Williamsburg), was educated at this college. After completing the usual course here, he studied physic at Edinburgh; was a favourite pupil of the celebrated BLACK; and gained much applause by his treatise, *De Calore*. Indeed, I have lately seen in the *Annales de Chemiè*, I think, for the year 1800, the confession that Dr. M'CLURG first started the idea concerning heat, which the French philosophers have since pursued with so much success." —*MS. Letter from the Rev. Dr.* MADISON *to the Author.*

Frigorific Mixtures. p. 94.

The first person who made experiments on *freezing mixtures*, was M. FAHRENHEIT, of Amsterdam, at an early pe-

riod of the eighteenth century. But the subject was much more completely investigated by Mr. WALKER, in a paper published in the *Philosophical Transactions*, for 1795. Since that time, several curious additional experiments have been made by Professor LOWITZ, of Petersburgh, particularly the introduction of *muriate of lime*, which produces a very great degree of cold when mixed with snow. The experiments of LOWITZ have been lately repeated and extended by Mr. WALKER. By means of the above-mentioned mixture, Mr. W. H. PEPYS, junior, of the London Philosophical Society, with the assistance of some friends, froze, on the eighth of February, 1799, fifty-six pounds averdupois of mercury into a solid mass. In this process, the mercury in Fahrenheit's thermometer sunk 62 deg. below 0. a degree of cold never before produced in Great-Britain.

It is scarcely necessary to add, that these *frigorific* mixtures produce their effect, by the great and sudden absorption of caloric, which the materials occasion when brought together.

Light. p. 95.

Modern philosophers have discovered that the influence of light on growing *vegetables* is great and important. Plants may be made to vegetate tolerably well in the dark; but in that case their colour is always white, they have scarcely any taste, and contain but a very small portion of combustible matter. In a very short time, however, after their exposure to light, their colour becomes green, their taste is rendered much more intense, and the quantity of combustible matter is considerably increased.—THOMPSON'*s Chemistry*.

"It has been found by Dr. HERSCHELL (see *Philos. Trans.* for 1800) that the rays of light differ in their power of illuminating objects: for if an equal portion of each of these rays, one after another, be made to illuminate a minute object, a printed page, for instance, it will not be seen distinctly at the same distance when illuminated by each. We must stand nearest the object when it is illuminated by the *violet*. We see distinctly, at a somewhat greater distance, when the object is illuminated by the *indigo* ray; at a greater when by the *blue;* at a still greater when by the deep *green;* and at the greatest distance of all when by the lightest *green* or deepest *yellow*. We must stand nearer when the object is illuminated by the *orange* ray; and still nearer when by the

red. Thus it appears that the rays towards the middle of the spectrum possess the greatest illuminating power, and these at the extremity the least; and that the illuminating power of the rays gradually diminishes from the middle of the spectrum towards its extremities."—*Ibid.*

Carbon and Diamond the same. p. 96.

As the diamond is not affected by a considerable heat, it was for many ages considered as incombustible. Sir ISAAC NEWTON observing that combustibles refract light more powerfully than other bodies, and that the diamond possesses this property in great perfection, suspected it, from that circumstance, to be capable of combustion. This singular conjecture was verified, in 1694, by the Florentine Academicians, in the presence of COSMO III. Grand Duke of Tuscany. By means of a burning-glass they consumed several diamonds. FRANCIS I. Emperor of Germany, afterwards witnessed the destruction of several more in the heat of a furnace. These experiments were repeated by ROUELLE, MACQUER, and DARCET, who proved that the diamond was not merely evaporated, but actually burnt, and that if air was excluded it underwent no change.

No attempt, however, was made to ascertain the product till 1772. LAVOISIER, in a memoir published that year, showed that when the diamond is burnt *carbonic acid gas* is obtained, and that there is a striking analogy between it and charcoal. In 1785 GUYTON-MORVEAU found that the diamond is combustible when dropped into melted nitre; that it burns without leaving any residuum, and in a manner analogous to charcoal. This experiment was repeated with more precision by Mr. TENNANT, in 1797. (See *Philos. Trans.* for 1797.) The conclusion which he drew from it was, that when diamond is burnt, the whole of the product is carbonic acid gas; that a given weight of diamond yields just as much carbonic acid gas as the same weight of charcoal; and that diamond and charcoal are both composed of the very same substance. Or rather, to speak more precisely, diamond is pure carbon, while charcoal is a compound of carbon, or diamond and oxygen, or it is what the French call an *oxyd of diamond*. Hence the difference of colour, hardness, specific gravity, and electrical properties, between common *charcoal* and the precious stone called *diamond*.—THOMPSON'S *Chemistry*.

Thermometer. p. 103.

In FAHRENHEIT's Thermometer the *freezing* point is fixed at 32 deg. and the *boiling* point at 212 deg. In REAUMUR's, or rather DE LUC's, the freezing point is 0, and the boiling point 80 deg. In DE L'ISLE's, the usual order of graduation is inverted, the freezing point being 150 deg. and the boiling point 0. And, finally, in the thermometer of CELSIUS, the point of freezing is marked 0. and that of boiling 100 deg. To reduce the degrees of REAUMUR to those of FAHRENHEIT, the following formula may be employed: $\frac{R \times 9}{4} + 32 = F$. To reduce the degrees of CELSIUS to those of FAHRENHEIT, the following is sufficient: $\frac{C \times 9}{5} + 32 = F$. To reduce the degrees of DE L'ISLE, under the boiling point, to those of FAHRENHEIT, say $212 - \frac{6 D}{5} = F$. To reduce those above the boiling point to FAHRENHEIT, say, $212 + \frac{6 D}{5} = F$.

Though NEWTON first pointed out the method of making tolerably good thermometers, the practical part of the art of forming and graduating them was greatly simplified by Mr. FAHRENHEIT, of Amsterdam, and by Dr. MARTINE, of St. Andrews, whose *Essay on the Construction and Graduation of Thermometers* is one of the best works on the subject extant. Professor VAN SWINDEN, also, of Franeker, and M. DE LUC, of Geneva, have written very ably and instructively on the subject of thermometers.

Eudiometers. p. 105.

The numerous *Eudiometers* proposed by different Chemists may be reduced to *five*.

1. The first is that invented by Dr. PRIESTLEY, in which *nitrous gas* is mixed, over water, with the air, the purity of which it is wished to ascertain. The diminution of the volume of this mixture is proportioned to the quantity of oxygen contained in the air, which is rapidly absorbed by the nitrous gas, and the nitric acid thus formed is also rapidly absorbed by the water. This eudiometer has received various

modifications and improvements by FALCONER, CAVENDISH, and VAN HUMBOLDT, but is still liable to considerable anomaly and inaccuracy in its indications.

2. The second kind of Eudiometer was proposed by VOLTA. His method was to mix given proportions of the air to be examined, and *hydrogen gas*, in a graduated glass tube; to fire the mixture by an electric spark; and to judge of the purity of the air by the bulk of the residuum. But this furnishes a measure even less to be depended on than the preceding.

3. SCHEELE was the inventor of the third kind of Eudiometer. It is merely a graduated glass vessel, containing a given quantity of air, exposed to newly prepared liquid alkaline or earthy sulphurets, or to a mixture of iron-filings and sulphur, formed into a paste with water. These substances absorb the whole of the oxygen of the air, which converts a portion of the sulphur into an acid. The oxygen contained in the air thus examined is judged of by the diminution of bulk which the air has undergone. This method is simple, and as accurate as any other. The only objection to which it is liable is the slowness of the process. But this objection has been removed by M. DE MARTI, who has brought the eudiometer of SCHEELE to a great degree of accuracy, by improving the apparatus, and, instead of iron-filings and sulphur, using the *hydrogenated sulphurets* only.

GUYTON-MORVEAU employs *sulphuret of pot-ash*, and measures the proportion of oxygen present by the quantity absorbed by the *sulphuret*.

4. In the fourth kind of Eudiometer, the abstraction of the oxygen of air is accomplished by means of *phosphorus*. This eudiometer was first proposed by ACHARD. It was considerably improved by REBOUL, SEGUIN, LAVOISIER, and, above all, by BERTHOLLET, who has rendered it equal in simplicity with the eudiometer of DE MARTI, and scarcely inferior to it in precision.

5. The fifth Eudiometer has been lately proposed by Mr. DAVY. In this the substance used to absorb the oxygen from the air is a solution of sulphat or muriat of iron in water, and impregnated with nitrous gas. This eudiometer is simple, and its indications nearly, if not quite, as accurate as those of the two last mentioned.—THOMPSON'S *Chemistry*.

NOTES ON CHAPTER III.

Collectors and Compilers in Natural History. p. 112.

AMONG the many persons who were busily engaged in collecting and publishing facts and delineations in Natural History, before the time that LINNÆUS began to flourish, the name of the learned and indefatigable ALBERT SEBA deserves particular notice. He resided in Holland, was intimate with BOERHAAVE, and compiled his large work on Natural History under the patronage of that eminent naturalist and physician. This work, under the title of *Thesaurus Rerum Naturalium*, was published in 1734, in four vols. folio.

ZOOLOGY. p. 114.

The statement, that little progress was made in Zoology between the time of RAY and that of LINNÆUS, is not correct. During that period (in the opinion of an excellent judge) "Zoology was cultivated with uncommon success, and received some of its happiest accessions. In particular, what may be called scientific Zoology was greatly attended to."

LINNÆUS. p. 114.

This "Prince of Naturalists" is so well known, that a formal account of him in this place is altogether unnecessary. He was born at Roeshult, a village of Sweden, May 27, 1707. His first great work was published in 1732. Among the numerous public honours with which he was crowned, he was created Knight of the Polar Star in 1753, and ennobled in 1757. He died in January, 1778, in the 71st year of his age.

BUFFON. p. 115.

GEORGE LE CLERC, Count DE BUFFON, was born in the year 1707 (the same year that gave birth to LINNÆUS), and

died April 16, 1788. He was one of the most voluminous writers on Natural History that the age produced: and although the faults imputed to him in the above-mentioned page are undoubtedly well founded, yet, perhaps, justice is scarcely done to his splendid talents, and his no less splendid publications in this science. Though he too much neglected philosophical arrangement; though he adopted and endeavoured to propagate a number of gross errors; and though he discovered particular opposition to Revealed Religion; still it cannot be denied that he made many rich additions to the science of Natural History, and will always be entitled to a place among its most zealous, acute, and successful cultivators.

Pennant. p. 116.

Thomas Pennant, LL. D. F. R.S. was born in Flintshire, in South-Britain, in the year 1726, and died in 1798. From an early age he discovered an enthusiastic fondness for investigations in Zoology, which he cultivated with great diligence, ability, and success. The following list of publications by this amiable man (though it does not contain, it is believed, all his works) will show that he was one of the most voluminous writers of the age.

British Zoology, four vols. 4to. 1750.
Tour to Scotland, three vols. 4to. 1771.
Synopsis of Quadrupeds, 8vo. 1771.
Tour to Wales, two vols. 4to. 1778.
Journey from Chester to London, one vol. 4to. 1782.
Arctic Zoology, three vols. 4to. 1784.
History of Quadrupeds, two vols. 4to.
Indian Zoology, one vol. 4to.
Genera of Birds, one vol. 4to.
Natural History of Holywell and Downing, one vol. 4to.
View of Hindostan, two vols. 4to.
London, one vol. 4to.

He left behind him, in manuscript, a large work, entitled *Outlines of the Globe*, of which his *View of Hindostan* formed the 14th and 15th volumes!

Natural History of Man. p. 117.

Albinus is improperly mentioned as the first naturalist who attended, in a scientific manner, to the seat of *colour* in hu-

man beings. To MARCELLUS MALPIGHI, in the 17th century, we certainly owe the discovery of the fact, that the colour of negroes resides in a peculiar body, the *corpus mucosum*. This fact was also known to J. N. PECKLIN, as early as 1677, as appears by his work *De Habitu et Colore Ethiopum*, &c. published that year.

Among the writers on this subject it is also proper to take notice of Dr. JOHN MITCHELL, an English physician, who resided a number of years in Virginia. His *Essay on the Causes of the different Colours of People*, published in the *Philosophical Transactions*, vol. xliii. p. 102—150, is considered as a very honourable monument of his learning and talents.

It is generally known that some naturalists of the eighteenth century attempted to undermine the credibility of the Mosaic history, by adducing what they considered proof, that there are different races of men, and, of course, that mankind could not have sprung from a single pair. Against this hypothesis, the Rev. Dr. SMITH's ingenious and learned *Essay on the Causes of the Variety of Complexion and Figure in the Human Species*, was particularly directed. Professor BLUMENBACH, of Göttingen, who has written still more largely on the subject, is also an able advocate of the Sacred History. The latter, by a curious induction of facts concerning the effects of *climate*, &c. on other species of animals as well as man, has thrown new light on this interesting question.

Dr. BLUMENBACH's work, *De Generis Humani Varietate Nativa*, was first published in 1775, in the form of an Inaugural Dissertation. It has been greatly improved in subsequent editions, and is a work of much merit, particularly considered as an able compilation.

Of those who have made valuable additions to the natural history of man, by means of inquiries into the origin, progress, and affinities of different *languages*, several other names ought to be mentioned besides that of Sir WILLIAM JONES. Among this number, Mr. JACOB BRYANT, of Great-Britain, M. COURT DE GEBELIN, of France, and Professor PALLAS, before mentioned, hold a distinguished place. Still more recently, new and important light has been thrown on this subject by Professor BARTON, of Philadelphia, who, in his *New Views of the Origin of the Tribes and Nations of America*, has published *Vocabularies* of a number of Indian

languages that were never before committed to the press; has compared these with languages more generally known, both on the eastern and western continents; and has thence deduced new evidence in support of the opinion that the nations of America and those of Asia have a common origin, and that all mankind are derived from a single pair.

Several of the writers on the natural history of man, mentioned in pages 117 and 118, have delivered opinions grossly deceptive and erroneous; but to enter into a particular discussion of their comparative merits cannot be undertaken in this place.

Fossil Bones. p. 119.

Besides the writers enumerated in the above-mentioned page, who have greatly distinguished themselves by their inquiries on the subject of *fossil bones*, it would be improper to pass without notice two others, who gained considerable reputation by their labours on this subject. The first is Dr. BREYNIUS, or BREYNE, a German, who was contemporary with Sir HANS SLOANE, and who published some papers on this branch of zoology in the *Philosophical Transactions*. He was among the earliest writers, and, it is believed, the very first of any distinction who wrote on the subject of fossil bones. The second is the Abbè FORTIS, who, in his *Travels in Dalmatia*, also gave some interesting and instructive information on this subject.

M. CUVIER, of France, a member of the National Institute, and a celebrated zoologist, has been for some time engaged in a very extensive work upon the species of quadrupeds, whose bones have been found in the interior parts of the earth. He has undertaken to settle the controversy concerning these animal relics. He says, that the strata of every country upon earth contain bones different from those of the animals which now inhabit their surface: that, with the single exception of ruminant animals, all the complete fossil bones which he has seen, are different from those of quadrupeds now alive: that of these he has been able to ascertain *twenty-three species*, all certainly unknown at this day, and which appear to have been entirely destroyed, though their bones evince their existence in former ages.

These species of creatures, whose races are now extinct, M. CUVIER divides into two classes—1. Those which have been determined by others; and, 2. Such as have been settled by himself. In the first he enumerates the following: 1. The *Siberian animal* which affords fossil ivory. 2. The *mammoth*, differing from the former chiefly in the size and points of its grinders. 3. The *long-headed rhinoceros*. 4. That animal of the *tardigrade family* called *megatherium* and *megalonyx*. 5. An extinct species of *large bear*. 6. *Another species* of the bear. 7. A *carnivorous animal*, intermediate between the wolf and hyæna. 8. A *creature a-kin to the moose*, whose horns measure fourteen feet from tip to tip. 9. The great *fossil tortoise*. 10. The *Maestricht crocodile*. 11. A *sort of dragon*. 12. An unknown kind of reptile or cetaceous animal.—In the second class, the chief of which have been discovered in France, M. CUVIER places the following species: 1. The animal whose *teeth, when impregnated with copper*, form the occidental turquoise. 2. A *tapir*, differing from that of South-America only in the form of its grinders. 3. *Another tapir*, of a gigantic or elephantine size. 4. A *species of hippopotamos*, of about the size of a hog. 5, 6, 7, 8, 9, 10. Six fossil skeletons of an unknown species, between the rhinoceros and the tapir, from the plaster-quarries in the neighbourhood of Paris. 11. A species of crocodile, considerably like that of the Ganges.

But these are not all which the earth contains: there are *parts* of skeletons of which M. CUVIER cannot speak with equal assurance; but of which, however, enough is known to encourage a hope, that the list of zoological antiquities will be soon lengthened. Of these, some resemble the bones, 1. Of the tiger. 2. Of an hyæna, or sea-calf. 3. Of the fallow-deer. And others of uncertain characters; as the petrified bones, 1. Near Verona. 2 and 3. Two sorts in the Rock of Gibraltar. 4. In the vicinity of Dax. 5. Near Orleans. 6. Near Aix and Cette. 7. In the islands of Dalmatia, &c. And, 8. All other *uncertain bones* found in the peat-mosses of all parts of Europe and Asia. In the course of a short time M. CUVIER hopes to determine the exact place in the system to which these doubtful species are to be referred.

M. CUVIER solicits information on these subjects from all parts of the world. He wishes to procure the bones themselves, or figures of them, or correct descriptions in words.—*Medical Repository.*

The naturalists of France derived great advantages when Holland fell into the power of their countrymen, from the opportunities which were afforded them of inspecting the rich Museum of the Stadtholder. M. CUVIER's attention was more particularly directed to two elephants' heads, which having examined with some nicety, he found to exhibit characters that warrant their being considered as belonging to two distinct species. One of them from Ceylon, he remarked differed from the other (which came from the Cape) in respect not only to the general contour of the forehead, but to the shape of the teeth, which last he was at length induced, like BLUMENBACH and others, to constitute the distinguishing characteristics of elephants in general, and extending his inquiries to such as we know only by their fossil *exuviæ*, he has furnished us with the following specific descriptions. *viz.*

" *Elephas Capensis, fronte convexa, lamellis molarium rhomboidalibus.*

E. Indicus, fronte plano-concava, lamellis molarium arcuatis undatis.

E. Mammonteus, maxilla obtusiore, lamellis molarium tenuibus rectis.

E. Americanus, molaribus multi-cuspidibus, lamellis post Detritionem quadrilobatis."

C. CUVIER has, since the publication of his Memoir, discovered several new species of elephants, differing not only from the fossil ones hitherto described, but from all living animals with which we are acquainted. One of them is found in Peru, and other countries, and comes nearest to the elephant of the Ohio: Another has been discovered in the *strata* of the black mountain, in the department of L'Herault: A third is found at Comminge; and fragments of the fourth abound in the vicinity of Paris.—*Mem. de l'Inst.* tom. ii. p. 22.

The origin of these *fossil bones*, especially of some, found in peculiar circumstances, has employed the ingenuity of many eminent naturalists, and been made the subject of much speculation in later years. On the supposition, which has been adopted by a considerable number of these inquirers, that the account given in the sacred writings of the general *Deluge* is false, the question is, indeed, of difficult solution. But, admitting the truth of that account, (and every mountain and valley lifts up its voice to confirm it), the difficulty, in a great measure, if not entirely, vanishes. Let us suppose that the animals whose fossil *exuviæ* are now found were

inhabitants of the antediluvian world, is it not evident that many of the facts observed, are precisely such as must necessarily have arisen from this state of the case?

The fossil remains of *elephants* have been discovered in various parts of the *North-American* continent, where none of this genus of animals are now to be found in the living state. This has been made a wonder. But how could it have been otherwise? If the *Flood* destroyed all the inhabitants of the earth, except those which were preserved in the *Ark;* and if the ark rested, after the subsiding of the waters, on the Eastern continent, as is generally supposed by biblical commentators, then no animals, excepting those capable of making occasional and considerable expeditions by *water*, or of living in frozen regions, and by this means passing from the Eastern to the Western continent on the ice, could be expected to be found in the latter, in any other than the *fossil* state. It is true, we find animals in South-America which appear, at present, only capable of inhabiting warm regions; but it is well known, that both animals and vegetables have the faculty of accommodating themselves to the climate in which they are placed, and of gradually changing their character. It is by no means improbable, therefore, that the ancestors of the animals now living in South-America had once a northern constitution; that after crossing the strait between Asia and America, they gradually strayed further south; and that, in process of time, their offspring acquired southern habits and constitutions.

Nor is it by any means difficult to suppose, that these fossil *exuviæ* were deposited in the places where they are found, at the subsidence of the waters of the general deluge. They have been generally found in circumstances calculated long to preserve them; in strata of earth which tend to resist putrefaction, and which may account for their remaining entire after so great a lapse of time.

Quadrupeds. p. 119.

Among the zoologists who have directed particular attention to *Quadrupeds*, during the last age, may be reckoned PENNANT, of Great-Britain, BRISSON and DAUBENTON, of France, KLEIN, BLUMENBACH, and SCHREBER, of Germany, and PALLAS, of Russia. Besides these, LINNÆUS, BUFFON, and ZIMMERMAN, treated ably on this as well as other departments of zoology.

Birds. p. 120.

Among those who have contributed to the improvement of Ornithology, SPARRMAN, of Sweden, is entitled to an honourable place. The plates of his *Museum Carlsonianum* are among the best that were ever published. They are said to be less tawdry and more natural than those of BUFFON.

The *Ornithologie* of BRISSON is worthy of more pointed and respectful notice than is taken of it in the above-mentioned page. It has been pronounced, by some good judges, to be, so far as respects the description of the species of birds, one of the most accurate works that have hitherto appeared.

A new classification of *Birds* has been presented to the public by PAUL H. G. MOEHRING, of Germany, who died in 1792; and, still more recently, a new arrangement of the same class of animals has been made by LA CEPEDE, of France.

Amphibia. p. 121.

Besides the writers on the *Amphibia* noticed in the above-mentioned page, the names of several others deserve to be introduced here with great respect. Several genera of this class were ably illustrated by J. N. LAURENT, of Germany. The *Lizards* and *Serpents* have been well treated by B. MERREM, of the same country; the *Serpents* by FONTANA; the *Tortoise* by SCHNEIDER, of Germany; and the *Frogs* by ROESEL, also a German.

ROBERT TOWNSON, LL. D. a respectable naturalist of Great-Britain, has contributed to extend our knowledge of the physiology of the *Amphibia*. See *Tracts and Observations in Natural History and Physiology*, 8vo. London. 1799. This is a work of considerable merit. It contains many original observations concerning the respiration, absorption, &c. of the Amphibia.

Fishes. p. 122.

In addition to the great Ichthyologists mentioned in this page, some others, during the period in question, hold a high place in the history of zoology. SCOPOLI, KLEIN, and GRONOVIUS, treated ably of this class of animals.

The *Philosophia Ichthyologica* of ARTEDI, especially the second edition (1792), by Dr. WALBAUM, of Lubeck, in three vols. 4to. may be considered as one of the most valuable works on this subject produced during the age under review.—ARTEDI was a Swede, the cotemporary and friend of LINNÆUS. He was born in 1705, two years before his illustrious countryman; and died in 1735, being accidentally drowned in a canal at Amsterdam.

Insects. p. 123.

MARIA SYBILLA MERIAN, a celebrated German lady, was born in 1647, and died in 1717. She is, therefore, erroneously placed after LINNÆUS, who did not make his first publication till a number of years after her death. She rendered very important services to *Entomology*. Her great work, entitled *Surinaamsche Insecten* (folio 1705), was, at the time of its publication, one of the most magnificent that had ever been produced in Europe.

LINNÆUS first produced a systematic arrangement of *Insects*, at once sufficiently comprehensive, and in a due degree minute in its distinctions. He distributed all insects into *seven* orders, taking the distinctive marks from variations in the structure of the *wings*, or the entire absence of these organs. FABRICIUS formed a new system essentially different from that of LINNÆUS. He employs for the foundation of his arrangement, the diversities in those parts of the organization with which insects take their *food*.—The arrangement of LINNÆUS is commonly preferred, especially in Great-Britain; but that of FABRICIUS has many admirers on the continent of Europe.

When REAUMUR and FABRICIUS are mentioned together, and a place assigned them in the first rank of entomologists, it is to be remembered that each has a different kind of excellence. FABRICIUS is a great technical or systematic entomologist; but he has done, comparatively speaking, little in regard to the physiology or philosophy of the subject. In this point of view nothing has appeared that will bear a comparison with the great work of REAUMUR.

Important contributions to the natural history of *Insects* have also been made, during the period under consideration,

by FRISCH, ROSENHOF, KLEEMAN, ROESEL, SULZER, SCHAFER, and several others, of Germany; and also by Professor PALLAS, whose *Icones Insectarum* is a very valuable work.

BONNETT. p. 123.

CHARLES BONNETT was born in 1720, at Geneva, where he died in 1793. He was one of the most distinguished men of the eighteenth century. His inquiries and publications on *Insects* and the *Vermes* are greatly esteemed, and have been much celebrated among naturalists.

Vermes. p. 124.

Besides the writers on the *Vermes* noticed in the page above-mentioned, this class of animals has been treated, either generally or in part, by JOH. A. MURRAY, JAC. THEOD. KLEIN, NATH. GOTH. LESKE, and ZEDER, all of Germany, and by the still more celebrated SPALLANZANI, of Italy. The last mentioned writer paid particular attention to the *Corallines*, and other marine productions, and to the *Infusoria*.

Number of Birds known. p. 125.

According to the latest accounts given by M. LA CEPEDE, of France, who has given, as was before observed, a new arrangement of Birds, there are now known *two thousand five hundred and thirty-six* species.

Zootomy and Physiology.

The inquiries of the naturalists of the eighteenth century, respecting the structure of different animals, and the functions of their respective organs, may be considered as forming one of the most remarkable distinctions of modern times. Among these, the first and second MONRO, WILLIAM and JOHN HUNTER, HEWSON, CRUIKSHANK, COLLINS, STUBBS, COLEMAN and HOME, of Great-Britain; DAUBENTON,

REAUMUR, DU VERNEY, VICQ-D'-AZYR, CUVIER, BROUSSONET, and DICQUEMARE, of France; BLUMENBACH, of Germany; SPALLANZANI, of Italy; CAMPER, of Holland; and many others in different parts of Europe, deserve to be honourably mentioned.

SARRAGIN. p. 126.

M. SARRAGIN, a French physician, who resided for some time in Canada, well deserves to be added to the list of those who have considerably extended our acquaintance with the animal and vegetable productions of the higher parts of North-America. His different memoirs were published between the years 1706 and 1728. His anatomical histories of the *Beaver, Muskrat and Porcupine*, are valuable. M. SARRAGIN likewise distinguished himself by a publication on the *Sugar Maple (Acer Saccharinum)* of our country. That remarkable family of plants denominated *Saracenia* was so named in honour of this writer, by the illustrious TOURNEFORT.

BOTANY.

RAY'S *Method.* p. 128.

There is a mistake in the above-mentioned page with respect to the year in which RAY published his second and improved method of arranging vegetables. It was in 1703. In his first method he divided the vegetable kingdom into 25 classes, of which *Trees* and *Shrubs* formed the two first, and *Herbs* the remaining 23. This was published in 1682, twenty-one years before his second method.—He is said to have been one of the greatest naturalists and best men of the age in which he lived.

HERMANN. p. 129.

PAUL HERMANN was a native of Saxony, and died in 1695. It would be more correct to say that he arranged plants according as their seeds are *naked* or enclosed in a *pericarp*. This learned man not only presented to the world botanical writings of great value, but also *engravings* of

plants, which are executed with much delicacy, considering the period at which he lived.—BARTON's *Botany*.

CHRISTOPHER KNAUT. p. 130.

CHRISTOPHER KNAUT's botanical system is represented in the above page as published about the same time with that of CHRISTIAN KNAUT. This is a mistake. His work, entitled *Enumeratio Plantarum circa Halam Saxorum sponte provenientium*, was published at Leipsic in 1687.

PONTEDERA's *Method*.

In 1720, the same year in which MAGNOL, of France, published his system, there was another offered to the world by JULIUS PONTEDERA, a nobleman of Pisa. He attempted to combine the systems of TOURNEFORT and RIVINUS.

LINNÆUS's *Methodus Calycina*.

Besides his *sexual* system, the great Swedish naturalist founded a method of arrangement on the form and other circumstances of the *Calyx*. To this method, which he published in the year 1737, he gave the name of *Methodus Calycina*. In this system the vegetable kingdom is divided into *eighteen* classes.

LUDWIG's *Method*.

CHRISTIAN GOTTLIEB LUDWIG, a native of Silesia, and a professor at Leipsic, published a new method in 1737, in which he divided vegetables into *twenty* classes, taking their distinctive characters from the *flower*. LUDWIG was the author of several valuable works, of which his *Institutiones Historico-Physicæ Regni Vegetabilis*, &c. printed at Leipsic in 1757, is the principal one.

Method of SAUVAGES.

In 1751 the celebrated Nosologist, FRANCIS BOISSIER SAUVAGES, of Montpellier, published his *Methodus Folio-*

rum, seu Plantæ Floræ Monspeliensis juxta Foliorum Ordinem. In this work the author has attempted an arrangement of plants from the situation or position of the *leaves.* It is believed that no succeeding botanist has adopted this method; nor, indeed, is its character such as will probably gain extensive favour.—BARTON'*s Botany.*

THUNBERG'*s Alteration of the Sexual System.* p. 138.

Professor THUNBERG, of Upsal, proposed, a few years ago, to alter the method of LINNÆUS, by suppressing the classes *Gynandria*, *Monoecia*, *Dioecia*, and *Polygamia*, and assigning to other classes the vegetables arranged by LINNÆUS and his followers under these denominations. The Professor has pursued this method in his *Flora Japonica*, and in his *Prodromus Floræ Capensis.* It is not generally considered as an improvement on the method of LINNÆUS, but rather as rendering it, on the whole, still more artificial and perplexed. In this alteration, however, he has been followed by GMELIN, WITHERING, SWARTZ, and several other eminent botanists.

Vegetable Physiology. p. 138.

The light thrown on *Vegetable Physiology*, during the period under review, forms one of its most brilliant honours. Little had been done in this branch of botanical science before the commencement of the eighteenth century. GREW and MALPIGHI, indeed, of the preceding age, had instituted some enlightened inquiries into the structure of plants; but they made little progress, compared with what has since been done. Early in the century under review, the Rev. Dr. HALES, of Great-Britain, pursued this investigation with great acuteness and diligence, and in his *Vegetable Statics* presented the world with a mass of information which will be long read and admired. About the same time, DUHAMEL, of France, was busily and successfully engaged in similar inquiries, and in his *Physique des Arbres*, and other publications, shed much new light on this part of botanical science. DUHAMEL was followed by CHARLES BONNETT, of Geneva, who proved one of the most distinguished vegetable physiologists of the age. His *Traité des Feuilles* is particularly curious and valuable.

Towards the close of the seventeenth century some attention had been paid to the different kinds of hairs which constitute a downy covering upon the surfaces of vegetables. But it was not till the year 1745 that this subject was treated in the full and masterly manner that it deserved. In that year M. J. STEPHEN GUETTARD, a very ingenious and learned French botanist, began to publish his observations on the *hairs* and *glands* of plants. These observations he continued during several succeeding years. He has even established a botanical *Method*, deduced from the form, the situation, and other circumstances of the hairy and other glandular appearances on the surface of plants. He has shown what, perhaps, would hardly have been suspected, that these appearances are, in general, constant and uniform in all the plants of the same family or genus. Hence, he has observed that they constitute good *generic*, but not *specific* characters. —BARTON's *Elements of Botany*.

Sir JOHN HILL, after much inquiry in vegetable physiology, published, in 1773, a very extensive work, which has been commonly called his *Vegetable System*, in which he proposes a method of arrangement founded on the *internal structure* of plants. About the same time, M. TILLET, of France, and the celebrated SPALLANZANI, of Italy, published the results of their observations and experiments on the organs and functions of vegetables, which have been generally considered as highly valuable. Besides what has been done by these naturalists, new light has been thrown on vegetable physiology by Professor WALKER and Dr. DARWIN, of Great-Britain; by DES FONTAINES and VAUQUELIN, of France; by PONTEDERA, of Italy; by SENNEBIER, and SAUSSURE, senior and junior, of Geneva; and by PLENCK and REICHEL, of Germany.

But among the vegetable anatomists and physiologists who flourished towards the close of the eighteenth century, JOSEPH GÆRTNER, of Germany, deserves particular distinction. This great botanist was born in the year 1732, and died in 1792, at the age of 59. He early devoted himself to the *fruit* of vegetables, not only as a part of vegetable physiology which had been too much neglected, but also as furnishing one of the best grounds of botanical arrangement. A method of this kind he exhibited in his great work, *De Fructibus et Seminibus Plantarum*, the first volume of which was published in 1788, and the second in 1791: a work which abounds with valuable instruction in botanical science; and though the method

which it contains is by no means free from objections, the author is entitled to much commendation for his labour, and must ever be ranked among those who have made large contributions to our knowledge of the vegetable kingdom.

The modern discoveries in chemistry have contributed much to enlarge our acquaintance with the composition, food, and growth of plants. Several of the vegetable physiologists mentioned in the foregoing paragraphs have rendered important aid to this branch of inquiry. To these may be added PRIESTLEY, of Great-Britain; HASSENFRATZ, FOURCROY, CHAPTAL, GIOBERT, and PARMENTIER, of France; and INGENHOUZ and VON HUMBOLDT, of Germany; whose experiments and various works have thrown new and very important light on some of the laws of vegetation.

Additional Systems of Botany. p. 139.

Botanical methods, either partly or wholly original, have been proposed by HEISTER, NECKER, and MEDICUS, all of Germany; but the author has too little knowledge of them to attempt an account of their structure or merits. Modifications and improvements of the Linnæan system have also been proposed by the celebrated SCHREBER, of that country. But with the peculiar character of these too the author is unacquainted.

Writers on particular Classes, or Families of Plants. p. 139.

Perhaps no class of plants has been investigated since the time of LINNÆUS with greater zeal and labour than the *Cryptogamia.* Besides the writers on this department of botany, enumerated in the above-mentioned page, the names of M. TODE, M. BULLIARD, Professor BATSCH, M. DE BEAUVOIS, and several others, may be added to the list. Indeed, the plants of this class have been investigated with a species of zeal, which led a late botanist, M. DE NECKER, to denominate the enthusiastic rage for inquiries after them *Cryptomania.* But to no botanist are we so much indebted for important information respecting the *Cryptogamick* plants as to the late Dr. HEDWIG, of Leipsic.—BARTON's *Elements.*

One of the latest and best writers on the *Lichens* is ERIK ACHARIUS, M.D. a native of Sweden.—See his *Lichenographiæ Succiæ Prodromus,* 8vo. 1798.

Father PLUMIER was one of the first good writers on the *Ferns*. His *Traité des Fougeres de l'Amerique*, published in 1705, holds a high rank among the works on this part of botany.

The work of the Marquis de St. SIMON, on *Hyacinths*, (4to. Amsterdam, 1786) is worthy of respectful notice.

Before the work of M. C. HERETIER, on the *Geranium*, Professor BURMAN, of Amsterdam, had written ably on that extensive family of plants.

Mr. ELLIS, of Great-Britain, (the celebrated writer on *Corallines*) has given the best botanical account of the *coffee-tree* that is extant.

Academic Dissertations on Botanical Subjects. p. 140.

At the close of the eighteenth century, only *five* dissertations, it is believed, had been published by the medical graduates of America on botanical subjects. These are respectfully noticed in the above-mentioned page. Since that time, publications of this kind have considerably multiplied. The learned and interesting lectures on botany, delivered by Professor BARTON, of the University of Pennsylvania, and his enlightened zeal in pursuing this branch of science, have produced a very sensible effect in recommending it to the attention of the students in that seminary. In the course of the last three years, the following dissertations on botanical subjects have been added to the former small list.

1. On the *Digitalis Purpurea*, by JOHN MOORE, of Pennsylvania.
2. On the *Kalmia Latifolia* and *Angustifolia*, by GEORGE THOMAS, of Virginia.
3. On the *Melia Azedarach*, by GRAFTON DUVAL, of Maryland.
4. On the *Prunus Virginiana*, by CHARLES MORRIS, of Virginia.
5. On the *Liriodendron Tulipifera*, by PATRICK ROGERS, of Ireland.
6. On the *Magnolia Glauca*, by THOMAS D. PRICE, of Virginia.
7. On the *Spigelia Marylandica*, by HEDGE THOMPSON, of New-Jersey.
8. On the *Sanguinaria Canadensis*, by WILLIAM DOWNEY, of Maryland.

9. On the *Bignonia Catalpa*, by ROBERT HOLMES, of Virginia.
10. On the *Polygala Senega*, by THOMAS MASSIE, of Virginia.
11. On the *Arbutus Uva Arsi*, and *Pyrola Umbellata* and *Maculata*, by JOHN S. MITCHELL, of Pennsylvania.
12. On the *Cornus Florida*, and *Sericea*, and the *Cinchona Officinalis*, by JOHN M. WALKER, of Virginia.

Some of these Academic publications have great merit. They afford conclusive evidence, that this department of Natural History is more studied in the middle and southern than in the eastern states. It will be observed, that the authors of all the dissertations above-mentioned, reside to the south of New-York, excepting the student from Ireland.

DILLENIUS. p. 141.

JOHN JACOB DILLENIUS was born in Germany, in 1687, came to England in 1721, was appointed Professor of Botany in the University of Oxford about the year 1729, which office he held till his death, in 1747. DILLENIUS made a number of botanical publications; but that which has more than any other immortalized his name is the *Historia Muscorum*, &c. 4to. 1741. Indeed, his discoveries in the natural history of the *Mosses* were so numerous and brilliant, that he deserves, more than any other individual, to be called the father of this branch of botany.

English Botany. p. 141.

To the list of writers on English Botany, given in the above-mentioned page, may be added Professor MARTYN, who has written ably on the subject; Mr. RELHAN, who has given a valuable *Flora Cantabrigiensis;* Mr. ABBOT, whose *Flora Bedfordiensis* is also a useful work; and Mr. SOWERBY, whose *English Botany*, and *English Fungi*, are worthy of much commendation. HILL and WILSON have also written on English plants.

SLOANE. p. 141.

Sir HANS SLOANE was born in Ireland, April 16, 1660. He studied medicine in London, where he long practised phy-

sic with great dignity and reputation. In 1687 he went to the island of *Jamaica*, in the character of physician to the Duke of ALBEMARLE, and touched at *Madeira*, *Barbadoes*, *Nevis*, and *St. Kitts*. He remained in *Jamaica* about fifteen months; returned to London in 1689; was chosen Secretary of the Royal Society in 1693; created a Baronet on the accession of GEORGE I. to the throne of Great-Britain, being the first English physician on whom an hereditary title of honour had been conferred; was advanced to the Presidency of the Royal Society in 1727; and died in 1752. To Sir HANS SLOANE the science of Botany is greatly indebted. His discoveries in the West-India islands were very numerous and valuable. These discoveries, though actually made in the seventeenth century, were not fully laid before the public till the beginning of the eighteenth. In 1707 he published the first volume of his great work, entitled *A Voyage to the Islands Madeira, Barbadoes,* &c. and in 1725 he completed it, by the publication of the second volume. This work may be considered one of the most valuable presents made to botanical science in the course of the age.—PULTENY'S *Sketches.*

HOUSTOUN. p. 141.

DR. WILLIAM HOUSTOUN, an English botanist, early in the eighteenth century, twice visited some of the West-India islands, where, on his second visit, in 1733, he died. By his labours the exotic botany of England was greatly enriched. His papers coming into the possession of Sir JOSEPH BANKS, were published in 1781, under the following title—*Reliquiæ Houstounianæ, seu Plantarum in America Meridionali, à Gulielmo Houstoun,* M. D. F. R. S. &c.—PULTENY'S *Sketches.*

PLUMIER. p. 141.

CHARLES PLUMIER was born at *Marseilles*, in the year 1646, and after receiving a classical education, at the age of sixteen, entered into the order of *Minime Friars*. He studied botany in a convent at Rome; and after paying considerable attention to this branch of natural history in his own country, he made three voyages to the West-India islands and the neighbouring continent, chiefly for the purpose of botanical

inquiries; the two latter at the expense of the French monarch. On his return from the third voyage he settled at Paris, in the character of his order, and in 1703 published his *Nova Plantarum Genera*. 4to. In this work, constructed on TOURNEFORT's method, the author described and presented the figures of 106 new *genera*, among which are many of the plants used in medicine. In 1704 he died at Port *St. Mary*, near Cadiz, when he was on the point of embarking for *Peru*, to discover and delineate the *Peruvian Bark Tree;* but before his death he had prepared for the press another great work, entitled *Traité des Fougeres de l'Amerique*, which was published in 1705, in folio, at the royal expense, and with royal magnificence.—PULTENY's *Sketches.*

CATESBY. p. 141.

For some account of MARK CATESBY, see vol. ii. chapter 26, of this work. His *Natural History of Carolina*, &c. was, at the time of its publication, in 1730—1743, the most splendid work of the kind that Great-Britain had ever produced; and, indeed, it had scarcely a rival in magnificence on earth. Many of the most beautiful and useful plants were, in this performance, for the first time, exhibited in their true proportions and natural colours. The number of subjects described and figured in the work is as follows: *Plants* 171—*Quadrupeds* 9—*Birds* 111—*Amphibia* 33—*Fishes* 46—*Insects* 31.

KALM. p. 142.

PETER KALM, the Swedish traveller in America, was a clergyman. On his return to his native country he was appointed Professor of Economy at *Abo*, where he died, November 16, 1779, aged sixty-three.

COLDEN *and* MUHLENBERG. p. 142.

Among the botanists enumerated in the above-mentioned page, Dr. COLDEN, and the Rev. Dr. MUHLENBERG, are represented as native Americans. This was inadvertently done. The former was a native of Scotland (see vol. ii. chap. 26 of

this work), and the latter is from Germany. Their long residence, however, in our country, gives us a kind of title to the honour of their scientific character.

CORNUTUS. p. 142.

CORNUTUS was erroneously mentioned among the botanists of the eighteenth century. His work was published in 1635.

The BARTRAMS. p. 142.

Two gentlemen of this name have contributed to our knowledge of American plants, viz. JOHN and WILLIAM BARTRAM, both natives of Pennsylvania. JOHN BARTRAM, the father, was born in the year 1701, and died in 1777. He was a self-taught philosopher and botanist. He travelled much in the American colonies, particularly to the southward and westward; discovered many new plants, and made large collections of our indigenous vegetables. (See vol. ii. chap. 26 of this work.) He made several valuable communications to PETER COLLINSON, on different subjects in zoology, which were published in the *Philosophical Transactions*, chiefly between the years 1743 and 1749. Professor BARTON is preparing for the press some account of this distinguished man, who may justly be styled " one of the fathers of natural history in North-America."—His son, WILLIAM BARTRAM, is still living, and advantageously known by his *Travels through North and South Carolina, Georgia, East and West Florida*, &c. He still cultivates the garden established by his father, and continues to devote himself to botanical inquiries and delineations with great zeal, and in a manner both useful and honourable to our country.

BARTON'*s Elements of Botany*. p. 142.

The work of Professor BARTON, announced in the above-mentioned page, as being then in the press, has since been published, under the following title—*Elements of Botany, or Outlines of the Natural History of Vegetables*, &c. 8vo. 1803. Dr. BARTON has the honour of being the first American who gave to his country an elementary work on Botany;

and if we may judge of the subsequent harvest by the first fruits, it will be rich indeed. This work is illustrated by *thirty plates*, and discovers an extent of learning, an acuteness and vigour of mind, and an elegance of taste, highly honourable to the author. Dr. BARTON adopts the *Sexual System*, and a great part of the Linnæan nomenclature; but is by no means a servile follower of that illustrious Naturalist. He thinks the sexual system would suffer no injury by the total abolition of the *eleventh* class *(Dodecandria)*; and though he dissents from the proposed alteration by THUNBERG, yet he thinks, with Dr. J. E. SMITH, that the *twenty-third* Linnæan class *(Polygamia)* is unnatural, variable, and obscure, and ought to be entirely suppressed.

Of the *thirty plates* which accompany this work, twenty-eight have claims to more or less originality, and many of them are completely original. They are well executed; and most of the subjects selected for delineation are remarkable for their rarity, their beauty, or some other peculiarity of character. Every part of this work discovers that the author has not been contented with compiling the facts and opinions of his predecessors, but that he has accurately observed and thought for himself. He will, therefore, no doubt, be pronounced, by the best judges, to have presented his countrymen with the most comprehensive, instructive, and satisfactory work of this kind in the English language.

Dr. GEORGE FORSTER. p. 143.

The Botany of the *South-Sea Islands* has also received new light from the *Florula* of those islands, published by Dr. GEORGE FORSTER, son of Dr. JOHN R. FORSTER, author of the *Nova Genera Plantarum.*

Delineations of Plants. p. 144.

Among the numerous and important services rendered to botanical science, by means of accurate and elegant *drawings*, and other modes of exhibiting plants, the following more particularly deserve notice.

It is a singular fact that Physic is indebted for the most complete set of figures of the medicinal plants to the genius and industry of Mrs. ELIZABETH BLACKWELL, a native of

Scotland, who, in 1739, published a splendid work under the following title—*A curious Herbal, containing five hundred Cuts of the most useful Plants which are now used in the Practice of Physic, engraved on Folio Copperplates, after Drawings taken from the Life.* 2 vols. folio. This ingenious lady, after she had completed the drawings, engraved them on copper, and coloured the prints with her own hands. It ought to be mentioned, to the honour of Mrs. BLACKWELL, that she undertook and went through this ingenious labour for the purpose of procuring her husband's liberation from prison, where he was confined for debt, and from which she extricated him in two years.—PULTENY'S *Sketches.*

"Mrs. DELANEY (an English lady) has finished nine hundred and seventy accurate and elegant representations of different vegetables, with the parts of their flowers, fructification, &c. according with the classification of LINNÆUS, in what she terms *paper-mosaic.* She began this work at the age of 74, when her sight would no longer serve her to paint, in which she much excelled. Between the age of 74 and 82, at which time her eyes quite failed her, she executed the curious *Hortus Siccus* above-mentioned, which, I suppose, contains a greater number of plants than were ever before drawn from the life by any one person. Her method consisted in placing the leaves of each plant, with the petals, and all the other parts of the flowers, on coloured paper, and cutting them with scissars accurately to the natural size and form, and then pasting them on a dark ground; the effect of which is wonderful, and their accuracy less liable to fallacy than drawings. She is at this time (1788) in her 89th year, with all the powers of a fine understanding still unimpaired. I am informed that another very ingenious lady, Mrs. NORTH, is constructing a similar *Hortus Siccus,* or *paper-garden,* which she executes on a ground of vellum, with such elegant taste and scientific accuracy, that it cannot fail to become a work of inestimable value."—*Botanic Garden,* Part ii. Canto ii. p. 51. New-York edit.

Botanic Gardens. p. 144.

The late royal government of France, for the promotion of botanical science, was in the habit of establishing *Botani-*

cal Gardens in various parts of her colonies, and of foreign countries. A piece of land, of moderate fertility and extent, hired or purchased at the public expense, served, in the distant country where it was situated, as an home for a Botanist, a repository for the seeds he might collect, and a nursery for the plants he should cultivate. From establishments of this nature, in distant regions, rich treasures of botanical specimens and information have been transmitted to France.

The late king of France provided two gardens of this kind in the United States; one in Bergen County, in the State of New-Jersey, within eight or nine miles of the city of New-York; the other in South-Carolina. The Botanist employed to superintend these, and to perform all the duties of a botanical pensionary, was M. ANDREW MICHAUX, who has lately distinguished himself by his *Histoire des Chênes de l'Amerique*, &c. Paris. 1801. folio.

The first person in America who conceived and carried into effect the design of a *Botanic Garden* for the reception and cultivation of American vegetables, as well as exotics, was the celebrated JOHN BARTRAM, mentioned in a former note. His establishment, though small, and scarcely worthy of the name, when compared with those of Europe, was respectable, considering the situation of the proprietor, and is now probably the best in our country. Those formed and supported by the French government, though calculated to answer the purposes intended, were also far from being regular or complete botanical gardens. Nothing that deserves this character has yet been established in America. It is hoped the plan now in execution by Professor HOSACK, of Columbia College, will be fostered by the public, and succeed better than any former attempts.

MINERALOGY.

Minerals are arranged either according to their *external characters*, or their *chemical composition*. The former is called an *artificial* method of classification; the latter a *natural* one. LINNÆUS was the first, and, indeed, the only mineralogist among the moderns, who undertook to form an arrangement of minerals from their *external characters* alone. And CRONSTEDT has the honour of being the first who introduced a *natural* method. ABRAHAM G. WERNER, the celebrated mineralogist of Freyberg, in Germany, in 1774,

attempted to combine these two methods; and since that time almost all the great writers on mineralogy have followed his example.

After the publication of the first regular system of LINNÆUS, and before the appearance of CRONSTEDT's great work, several other systematic writers attempted to form different arrangements of mineral bodies. Among these, WOLSTERDORF, CARTHEUSER, and JUSTI, all of Germany, deserve to be mentioned. But none of them retain their reputation, amidst the numerous discoveries and improvements, and the incomparably better writers produced in later times.

Chemical Analysis of Minerals. p. 146.

The progress which was made in the art of analyzing minerals, in the course of the last thirty years of the eighteenth century, cannot be contemplated without astonishment. "To separate five or six substances intimately combined together; to exhibit each of them separately; to ascertain the precise quantity of each; and even to detect the presence and the weight of substances which do not approach $\frac{1}{500}$ part of the compound, would, at no very remote period, have been considered as a hopeless, if not an impossible task. Yet all this, by means of the wonderful discoveries and improvements of MARGRAFF, NEUMANN, SCHEELE, BERGMAN, KLAPROTH, VAUQUELIN, and others, can now be done with the most rigid accuracy."—THOMPSON's *Chemistry*, vol. iv.

Crystallization. p. 151.

The subject of *Crystallization* engaged much of the attention of chemists and mineralogists during the eighteenth century. The first attempt to account for this phenomenon, in any manner which deserves the name of philosophical, was by Sir ISAAC NEWTON. He supposed the aggregation which takes place in this instance to be produced by the attraction which he had proved to exist between the particles of all bodies, and which acts as soon as these particles are brought within a certain distance of each other by the evaporation of the liquid in which they are dissolved. The regularity of their figure he explained, by supposing that, while in a state of solution, they were arranged in the liquid in re-

gular rank and file; the consequence of which, as they are acted upon by a power which at equal distances is equal, and at unequal distances unequal, will be crystals of determinate figures.—This explanation, which is worthy of the luminous and acute mind of its author, is now generally admitted as the true one, and has contributed much towards the elucidation of the subject.

Still, however, there remained various phenomena respecting crystallization, which required to be more fully explained. To effect this many attempts have been made, and several theories formed.

Rome de Lisle professed to have determined the primitive form of every crystallized substance, and to have ascertained that all other forms are only modifications of this.—See his *Crystallographie.*

Gahn, of Sweden, went further. Having broken a calcareous spar of a particular kind (dog-tooth), he found that the crystal was entirely composed of small rhombs, like those of the primitive calcareous spar.

Bergman seized upon this idea of his pupil; and as he combined an attention to geometry with physical science, he demonstrated that every crystal is composed of other small crystals, variously piled, but, in each case, according to certain laws of decrement. These little elementary crystals are called by him *constituent parts of a crystal.* In this manner Bergman developed the mechanical structure of various crystals, and showed that the primitive form often lies concealed in those very crystals which appear to deviate farthest from it.

M. Hauy pursued the idea, and applied it to various crystallized minerals. He is supposed to have shown, not only that every particular species of crystal has a primitive figure, and that the variations are owing to the different ways in which the particles arrange themselves; but also to have determined the laws according to which the decrements take place, after certain data which he assumed. His theory of crystallization has been much celebrated. It is generally considered as ingenious and plausible; and certainly manifests a degree of diligence, zeal, and mathematical skill, which entitle him to much commendation.—See Tilloch's *Philosophical Magazine*, Nicholson's *Journal*, and also a good abstract of Hauy's system in the *Supplement to the Encyclopædia Britannica.*

Silver Mine in the State of New-York. p. 156.

The most considerable mine of either of the precious metals of which the author has heard in the United States, is the *silver* mine in the town of Mount-Pleasant, Westchester County, State of New-York. This mine is near the margin of the Hudson, thirty-six miles above the city of New-York, and on land beloging to WILLIAM STREET, Esq. It was discovered about forty years ago; and, for some years before the revolutionary war, was wrought to tolerable advantage. The convulsions and derangements attending that struggle suspended the operations of the company engaged in the business, and they have not since been resumed.

GEOLOGY.

That the *inequality of declivity* exhibited by the sides or flanks of mountains, in every part of the globe, had any regard to the *points of the compass*, seems to have been first remarked by the celebrated Swedish geologist, TILAS. (See *Memoirs of Stockholm* for 1760.) But he seems rather to have directed his views to the elevation or depression of the surface of Sweden, than to the bearings of the declivities of mountains in general. BERGMAN first discovered that the declivities of the flanks of mountains bear an invariable relation to their different aspects. He found that, in mountains extending from north to south, the western flank is the steepest, and the eastern the gentlest; and that in mountains which run east and west, the southern declivity is the steepest, and the northern the gentlest. After BERGMAN, BUFFON took notice of the generality of this phenomenon; but his remark was confined to the eastern and western sides of mountains extending from north to south, having no reference to the north and south sides of those which run east and west. The same fact was afterwards observed, in a general or more partial manner, by HERMAN, LA METHERIE, FORSTER, PALLAS, and several others.

Towards the close of the eighteenth century, Mr. KIRWAN directed his attention to this subject, and endeavoured to assign the cause of this almost universal allotment of unequal declivities to opposite points, and why the greatest are directed to the west and south, and the gentlest to the east and north. He supposes that this fact is connected with the ori-

ginal structure of our globe; that it proves that mountains are not mere fortuitous eruptions, as some, within a few years past, have confidently advanced; and that it furnishes a powerful argument in favour of the Mosaic account of the creation, deluge, &c.—See *Transactions of the Royal Irish Academy*, vol. vii.

METEOROLOGY.

Weight of the Atmosphere. p. 190.

The eighteenth century is distinguished by the numerous and enlightened experiments which were made during this period to ascertain the *weight* of the atmosphere in different latitudes and situations. For these we are principally indebted to M. BOUGUER, M. CASSAN, and M. COTTE, of France; and to Sir GEORGE SHUCKBURGH, Lord MULGRAVE, and Mr. KIRWAN, of Great-Britain and Ireland.

Purity of the Atmosphere. p. 190.

Though the experiments on the *Eudiometer* were mentioned under the head of *Chemistry*, and in some respects belong to that department of science, yet they also belong to *Meteorology*, and have contributed to throw some light on this obscure subject. These experiments, and the inquiries connected with them, belong exclusively to the eighteenth century.

Atmospherical Electricity. p. 192.

All our knowledge of *Atmospherical Electricity* is the product of the eighteenth century. To this subject the attention of philosophers has been particularly drawn since the time of Dr. FRANKLIN's discovery that lightning and thunder are occasioned by the agency of Electricity.

"The most complete set of experiments on this part of meteorology were made by Professor BECCARIA, of Turin. He found that the air is almost always positively electrical, especially in the day-time, and in dry weather; that when dark or wet weather clears up, the electricity is always negative; and that low thick fogs, rising into dry air, carry up a great deal of electric matter. He ascertained that the mid-

day electricity of days equally dry is always proportional to the heat; that winds lessen the electricity of a clear day, especially if damp; and that, for the most part, when there is a clear sky, and little wind, a considerable quantity of electricity arises after sun-set, at dew falling. Considerable light has been thrown on the sources of atmospherical electricity, by the experiments of M. SAUSSURE, and other mineralogists. Air is not only electrified by friction, like other electric bodies, but the state of its electricity is changed by various chemical operations which often go on in the atmosphere. Evaporation seems, in all cases, to convey electric matter into the atmosphere; and SAUSSURE has ascertained that the quantity of electricity is much increased when water is decomposed, as when water is dropped on red-hot iron. On the other hand, when steam is condensed into vesicular vapour, or into water, the air becomes negatively electric. Mr. CANTON has ascertained that dry air, when heated, becomes negatively electric, and positive when cooled, even when it is not permitted to expand or contract; and the contraction and expansion of air also occasion changes in its electric state. It is discovered, therefore, by these experiments, that there are four sources of atmospheric electricity known; viz. 1. Friction; 2. Evaporation; 3. Heat and Cold; 4. Expansion and Contraction; not to mention the Electricity evolved by the melting, freezing, solution, &c. of various bodies in the contact of air.—THOMSON'*s Chemistry.*

HYDROLOGY.

Common Waters. p. 199.

The comparative qualities of *common waters*, whether falling in *rain*, or found in *springs*, *wells*, or *lakes*, have been observed and ascertained, during the eighteenth century, with a degree of intelligence and accuracy never before known. For the experiments and inquiries which have led to our knowledge on this subject, we are chiefly indebted to BERGMAN, SCHEELE, CARRADORI, HASSENFRATZ, and GUYTON-MORVEAU.

Sea Water. p. 199.

The taste, specific gravity, and other properties of *sea water*, have also been examined with new accuracy, and with new results, during this period. For many enlightened ex-

periments in this branch of Hydrology, we owe much to SPARRMAN, BERGMAN, Lord MULGRAVE, M. PAGES, M. BLADH, Dr. WATSON, and Mr. KIRWAN.

Mineral Waters. p. 199.

Mr. BOYLE may be considered as the first person who pointed out the method of examining mineral waters. He first ascertained the existence of air in water, and directed to a number of tests, by means of which conjectures might be made concerning the saline bodies which the water examined held in solution. He was soon followed by DU CLOS, of France, by HIERNE, of Sweden, and by several other philosophers in different parts of Europe, who made considerable additions to the tests employed, and the facts ascertained by BOYLE. In 1726 BOULDUC pointed out a method of precipitating several of the saline contents of water by means of alcohol. But it was not till after the discovery of *carbonic acid* by Dr. BLACK, that any great progress was made in ascertaining the composition of mineral waters. That subtle acid, which is so often contained in them, and which serves as a most powerful solvent to many of the earths, and even of metallic bodies, had thwarted all the attempts of former chemists to detect the composition of these liquids. Since the discovery of that acid, the analysis of mineral waters has advanced with great rapidity; so that, at the present period, this may be considered as one of the most advanced parts of chemical philosophy.—THOMSON'*s Chemistry.*

The Dissertation on the Analysis of Mineral Waters, published by BERGMAN in 1778, may be considered as the first great work on this subject. No general mode of analyzing mineral waters was known prior to this publication. The author, in this admirable work, not only shed much new light on the subject, but he also carried the investigation of it, at once, to a very high and honourable degree of perfection. His method, with many additions and improvements, has been generally adopted by succeeding hydrologists. He was followed by the distinguished persons whose names are enumerated in the above-mentioned page. Besides these, the names of BREZE and HASSENFRATZ are worthy of respectful notice, for their analyses of the waters of *Pu* and *Pougues.* Dr. PEARSON more particularly examined the waters of *Buxton;* Dr. GARNETT, those of *Harrowgate;* and Mr. LAMBE, those of *Lemington Priors.*

NOTES ON CHAPTER IV.

ANATOMY. p. 208.

THE family of MONRO, in Edinburgh, have been long and eminently distinguished in the annals of Anatomy. Three persons, of the name of ALEXANDER MONRO, have, in succession, adorned the medical school of that city, since the year 1720: of these, the last is yet alive, and ably supports the reputation of his illustrious family.

WILLIAM and JOHN HUNTER, also natives of North-Britain, and afterwards residents in London, hold a high place in the anatomical history of the eighteenth century. The former was born in 1718, and died in 1783; the latter was born in 1728, and died in 1793.

MASCAGNI. p. 212.

The work of MASCAGNI, on the *Lymphatics*, is too slightly mentioned. It is considered, by good judges, as by far the greatest work that has been published on this subject; as one of the most valuable anatomical productions of the age; and as a work that must immortalize the reputation of the author.

SCARPA. p. 213.

This great anatomist wrote ably, not only on the *Ear*, but also on the *Nerves of the Heart*. His work on this subject is said to be highly meritorious.

PHYSIOLOGY. p. 238.

The Abbè LAZARUS SPALLANZANI, of Italy, was born in the year 1729, and died in 1800. His researches and publications in several branches of natural history, especially in animal and vegetable physiology, place him among the most distinguished men of his age. On the subject of *Digestion*, he is, perhaps, the highest authority.

THEORY AND PRACTICE OF PHYSIC.

Medical Theory of STAHL. p. 260.

Among those who embraced either the whole or a part of the Stahlian doctrine, PAUL JOSEPH BARTHEZ is entitled to respectful notice. His work *De Principio Vitali Hominis*, published in 1773, and his *Nova Doctrina de Functionibus Naturæ Humanæ*, published in 1774, both deserve to be commended as indications of acuteness and ingenuity.

Doubts have been suggested whether GAUBIUS was really a follower of STAHL. Dr. HALLER represents him as *cautus vir, et in recipiendis opinionibus difficilis.* He is said, at any rate, never to have openly avowed his adherence to the *Stahlian* system.

PERRAULT wrote before STAHL. He died in the year 1688. From this writer it is not improbable that STAHL might have borrowed his celebrated doctrine.

HOFFMAN. p. 261.

FREDERICK HOFFMAN was born at Magdeburg, in the year 1660. The principal circumstances much known in the life of this illustrious physician, are, that he travelled into England and Holland, where he became acquainted with ROBERT BOYLE and PAUL HERMAN; that he never received any professional fees, being supported by his annual stipend; that he cured the Emperor CHARLES VI. and FREDERICK I. King of Prussia, of inveterate diseases; and that he had a very accurate and extensive knowledge, for that day, of the nature and virtues of mineral waters. HOFFMAN survived his 80th year; and his works were printed at Geneva, in six volumes folio, in 1740.

Dr. CULLEN. p. 264.

Dr. WILLIAM CULLEN was born in Lanarkshire, in the west of Scotland, December 11, 1712. He was chosen one of the medical professors in the University of Edinburgh in 1756, and died in that city in 1790, in the 77th year of his age. The various publications of this distinguished physi-

cian are so well known, that it is unnecessary to dwell on their merits. Of these, his *Nosologia Methodica*, his *First Lines of the Practice of Physic*, and his *Materia Medica*, are the most valuable.—See an eloquent and interesting *Eulogium upon Dr.* CULLEN, pronounced before the College of Physicians of Philadelphia, by Dr. RUSH. 8vo. 1790.

Dr. BROWN. p. 267.

Dr. JOHN BROWN was born in the village of Dunse, in Scotland, in the year 1735. His parents were in very humble life; and through his whole career he maintained a struggle with poverty. He began to teach medicine by public lectures in Edinburgh, about the year 1777: he removed to London in 1786, where he died in 1788, in the 53d year of his age. He was undoubtedly a man of great and original genius, and of considerable acquirements, but the unfortunate victim of folly and intemperance. His *Elementa Medicinæ*, first published by him in Latin, and afterwards translated by the author into English, has been so generally read, that it is needless to attempt a character of it in this place.

Dr. DARWIN. p. 271.

Dr. ERASMUS DARWIN was a native of Nottinghamshire, in South-Britain, where he was born, December 12, 1731. He was educated at the University of Cambridge, and graduated *Bachelor of Medicine* in that institution in 1755, and soon afterwards commenced the practice of physic at Litchfield, where he long resided in the honourable, useful, and profitable practice of his profession. His first great work, the *Botanic Garden*, was published in 1789; the *Zoonomia* in 1794; his *Phytologia* in 1799; and his *Temple of Nature* a short time after his death, which took place on the 18th of April, 1802.

Though the medical system of Dr. DARWIN is entitled to great praise as an effort of genius, and as an exhibition of much important truth; and though, in all his works, he manifests great strength and originality of mind, yet his philosophy, both physical and metaphysical, is chargeable with radical errors. The *atheistical* tendency of his speculations can scarcely be doubted; and his crude and visionary *philo-*

sophy of mind will not stand the test of sober inquiry. This, however, is not the place to enter into a discussion of these errors.

Small-pox. p. 283.

It has been made a question whether the *inoculation* of the small-pox ought to be considered as a blessing or an evil to society. Some have supposed that its effect has been to keep the disease more steadily alive, and more extensively diffused; and thus, on the whole, that it has produced an injury rather than a benefit. Professor WATERHOUSE, of Massachusetts, in a late publication, recommending the substitution of the *Cow-Pox*, makes the following statement:—"No less than forty millions of people die of the small-pox every century. The Europeans have carried the small-pox over the globe. The Danes carried it to Greenland, and the Spaniards to South-America, where one hundred thousand perished with it in the single province of Quito. When the annual number of births in London was sixteen thousand two hundred and ninety-one, the number who died with the small-pox was two thousand five hundred and fifty-four, and still greater in some other large cities of Europe. A greater number have died of the small-pox since the introduction of its inoculation than before it, that practice being the means of keeping it always in large cities."

Dr. DOUGLASS. p. 286.

Dr. WILLIAM DOUGLASS, who acted so violent and conspicuous a part in Boston, against the practice of inoculating for the small-pox, was the author of the work entitled, *A Summary of the British Settlements in America*, two vols. 8vo. London. 1755.

Materia Medica. p. 308.

In speaking of the *Apparatus Medicaminum* of Professor MURRAY, as "the most extensive, learned, and complete work" on the *Materia Medica* extant, the meaning is, that this is its character so far as it goes. The learned author

did not live to publish any thing on the mineral or animal articles of the materia medica. Professor GMELIN, of Gottingen, has published the *Mineral Materia Medica*, as a supplement to MURRAY's work; but he is not considered as having done justice to the subject.

Medical School of Kentucky. p. 324.

In enumerating the medical schools of the United States, that of Lexington, in Kentucky, was inadvertently omitted. This medical seminary was established, it is believed, in 1799, when Dr. FREDERICK RIDGELY was appointed Professor of the Practice of Physic, Obstetrics, and Materia Medica; and Dr. SAMUEL BROWN Professor of Anatomy, Surgery, and Chemistry.

Medical Science in America. p. 325.

There seems to be no science in which America has made more progress than that of Medicine; and none in which she holds a more complete independence of the doctrines and authorities of the European world. It is indeed true, that the physicians of this country were originally indebted to their preceptors in Europe for the elements of most of that knowledge which they have since so successfully laboured to simplify, improve and extend. It was natural to suppose, as so many of our most distinguished members of this profession had received their education in Europe, that they would remain fixed in the trammels of early impressions, and refuse to listen even to the evidence of facts, when found not to coincide with the principles they had deeply imbibed. Much of this blind reliance on authority has been observed; but it is equally true that America may boast of much free inquiry, and of much bold and successful innovation. This hemisphere is the theatre on which the prejudices and errors of the European schools, in a great variety of instances, have been refuted and abandoned, and on which new principles in medicine have been proposed, ascertained, and completely established. In support of this assertion it would be easy to adduce, not only the facts concerning American physicians who had been educated in Europe, and returned to their native country; but those likewise of European physicians going,

in various capacities, to reside in the West-Indies. Are diseases on this side of the globe more gigantic in stature, more marked and incapable of disguise in their features than in the land of our ancestors—or to what else are we to attribute this effect?

It would exceed the limits of this note, and appear unbecoming in the author, to enter into any discussion of the conflicting opinions of American and European physicians. Nothing more, therefore, than a rapid glance at the subject shall be attempted.

Medical science in America claims the merit of improvements and discoveries on the following subjects. A more simple and correct doctrine concerning the radical and universal relations of diseases; a more rational and practical estimate of nosology, the importance of which seems to have been greatly over-rated in Europe; more just, accurate and consistent opinions concerning the origin and causes of epidemic and pestilential diseases, according to which the notions of their importation and exportation from one country to another are rejected, and the doctrine of their production from a vitiated state of the atmosphere in the situations where they are found to prevail, is satisfactorily established; more correct principles on the subject of Quarantine, which might diminish the burdens and restrictions of commerce, and render the intercourse of nations more hospitable and humane; and a more extensive acquaintance with the medicinal virtues and uses of many articles of the vegetable kingdom.

Among many particular diseases and remedies, the management of which has been improved in the United States, the following may be selected with great confidence. A more simple and efficacious treatment of pestilential diseases; a more correct theory and practice in dropsy, particularly in that of the brain; a more discriminating, decisive and successful employment of blood-letting in fevers, and more just indications, founded upon the appearances of the blood after being drawn; and a more extensive and efficacious use of mercury in a variety of diseases.

In effecting these and many other improvements, the physicians of the United States have laboured with a laudable and enlightened diligence. In the first rank of those who have thus honourably employed their talents, it is proper to place the name of Dr. Rush, whose devotedness to science, and whose ardour, eloquence, and perseverance in the dissemination of it, will cause the period of his public instruc-

tion to be always hereafter considered as an interesting epoch in the history of medicine in this country. In truth, it may be asserted, that this gentleman, for a long period after the commencement of his course of public instruction, did more in his capacity of teacher than all the other physicians in the United States, collectively, to diffuse a taste for medical inquiries, and to excite a spirit of observation, and of laudable ambition, among the students of medicine in our country. The inquiries of Dr. MITCHILL, with respect to pestilential diseases, the subject of quarantine, &c. are likewise deeply connected with that mass of investigations in this country which commenced in throwing off the yoke of European authority, and asserting the rights of free and independent judgment. Nor is less praise due to Dr. BARTON, for his enlightened efforts to enrich the Materia Medica of the United States, by his researches into the virtues of their vegetable treasure.—Many other names might also be inserted in this place, were not the task of making a selection difficult and invidious.

NOTES ON CHAPTER V.

THE statement, at the beginning of this chapter, that, at the commencement of the eighteenth century, "almost half" the surface of the globe was in a great measure unknown, rather falls short of the truth than exceeds it. Perhaps it may be asserted that *five-sixths* were, at that period, scarcely at all known.

Additional Voyagers. p. 337.

Lieutenant SYND, in the Russian service, set out on a voyage of discovery in 1764, and returned in 1768. He steered a course more north-east than any of his predecessors, and made some valuable discoveries between Asia and America.

Among the Voyages which have contributed to the improvement of Geography, that which was performed, by order of the French king, in 1771 and 1772, by Messrs. DE

VERDUN DE LA CRENNE, of the Academy of the Marine at Brest, DE BORDA, Member of the Royal Academy of Sciences, &c. and PINGRE, Chancellor of the University of Paris, ought not to be omitted. Though the primary objects of this voyage were the making experiments on certain *Time-keepers* of LE ROY and BERTHOUD, and the investigation, in general, of the best mode of finding the longitude at sea; yet its able conductors made many other observations, and ascertained many facts of great importance to geographical science. They pointed out the true situation of a number of places, seas, and coasts, before but imperfectly known; rectified charts which had been long in vogue; and gave new and more accurate information on a variety of points highly interesting to navigators.

In 1775 Don JUAN DE AYALA, a Spanish navigator, undertook a voyage for the purpose of exploring the north-western coast of America. He added a little to the sum of geographical knowledge, by discovering some bays, capes, and harbours, between the 47th and 57th parallels of north latitude.

Our knowledge of *Iceland* was greatly improved by the voyage of Sir JOSEPH BANKS, and Dr. SOLANDER, to that island, in 1772. These gentlemen being disappointed in their plan of revisiting the South-Sea, determined on a northern voyage, in which they were accompanied by the Rev. Dr. VON TROIL, Dr. J. LIND, and several other literary and scientific gentlemen. They gave to the public, as the result of this expedition, much new and important information concerning the geography and natural history of Iceland.—See VON TROIL's *Letters on Iceland*. London. 8vo. 1780.

In 1785 Commodore BILLINGS, an Englishman in the Russian service, was dispatched by the Empress to explore some of the northern parts of Russia; more particularly to determine the latitude and longitude of the mouth of the River *Kovima*, and the situation of the great Promontory of the *Tshutski*, as far as the East Cape; to form an exact chart of the islands in the Eastern Ocean, extending to the coast of America; and, in short, to bring to perfection the knowledge acquired of the seas lying between Siberia and the opposite coast of America. Though this expedition did not answer the expectation of its royal patron, it furnished some additions to our geographical knowledge. Commodore BILLINGS, in particular, ascertained the latitude of the mouth of the *Kovima*, and returned to Petersburgh, in 1794, with a variety

of less important details of information, useful to navigation and geography.—See *An Account of a Geographical and Astronomical Expedition*, &c. by MARTIN SAUER. 4to.

In the years 1790, 1791, and 1792, a voyage round the world was performed in the ship *Solide*, commanded by Capt. ETIENNE MARCHAND, a French naval officer of reputation. From this voyage resulted the discovery of a group of islands in the Pacific Ocean, in the neighbourhood of the *Marquesas*, and some additional particulars of information respecting the north-west coast of America.

DAWKINS *and* WOOD. p. 339.

DAWKINS and WOOD travelled together in Syria. They were dispatched by the Dilletanti Society, chiefly for the purpose of exploring the ruins of *Balbeck* and *Palmyra*. On these they published two works, which were their joint productions; and contain little more than architectural sketches of buildings, with explanations. These travellers, therefore, are erroneously placed among those who have rendered much service to Geography. They brought to Europe little or no information, strictly speaking, on this subject.

DU HALDE. p. 340.

JEAN BAPTISTE DU HALDE was born in Paris, in 1674. He was extremely well versed in Asiatic Geography. His great work, entitled *Grand Description de la Chine, et de la Tartarre*, in four vols. folio, was compiled from original papers of the Jesuit missionaries. He was also concerned in a collection of letters begun by Father GOBIEN, entitled *Des Lettres Edifiantes*, in eighteen volumes. He died in 1743. —Though he appears so familiar with the geography, scenery and manners of China, he never was ten leagues from Paris in his life.

BELL. p. 340.

BELL is mentioned, by mistake, as having visited *Kamtschatka*. That respectable traveller never passed through any part of that country.

Siberia. p. 340.

For much important information respecting the geography of Siberia, we are indebted to PLENISNER, commander of Ochotsk, in the Russian service. He received orders from the court of Russia to proceed to Anadirsk, and to procure all possible information concerning the north-eastern parts of Siberia, and the opposite continent. He returned to Petersburgh in 1776, and brought with him several maps and charts of the north-eastern parts of Siberia, which were considered as highly authentic documents, and which were afterwards made use of in the compilation of the *General Map of Russia*, published by the Academy of Petersburgh in 1776.

Siberia has also been visited during the eighteenth century, and valuable information concerning the geography of that inhospitable region communicated by BELL, D'AUTEROCHE, PALLAS, and GMELIN.

KÆMPFER. p. 340.

Though KÆMPFER, the famous traveller in *Japan*, visited that island towards the close of the seventeenth century, yet, owing to his death, the account of his voyage was not published till 1727, when it was laid before the public by Dr. SCHEUCHZER, to whom KÆMPFER's manuscripts were committed by Sir HANS SLOANE.

RUMPHIUS. p. 341.

RUMPHIUS is erroneously mentioned as belonging to the eighteenth century. He belonged entirely to the seventeenth.

Africa. p. 343.

Among those who have contributed to elucidate the geography of *Africa*, Mr. LEDYARD is mentioned by mistake. The fact is, he was arrested by death so soon after setting out on his journey, that he cannot be represented as having done any thing to improve our knowledge of that quarter of the globe.

Among the modern travellers in *Africa*, HORNEMAN deserves respectful notice. His *Travels from Cairo to Mourzouk, the capital of the Kingdom of Fezzan*, in the years 1797 and 1798, added something to our knowledge of the interior of Africa.

Mr. BROWNE was inadvertently mentioned as having visited *Abyssinia*. He did not go into that part of Africa.

FLACOURT is placed by mistake in the eighteenth century. He lived in the preceding age.

Sir WILLIAM JONES has given the best account of the *Gomoro Isles* that is extant.—See the *Asiatic Miscellany*.

Turkish Empire. p. 347.

The travels of CHANDLER, TOURNEFORT, D'OHSSON, and OLIVIER, in the Turkish Empire, have thrown much new light on the physical and moral condition of different parts of that section of the globe.

North-America. p. 349.

Some of the best accounts of the physical and moral condition of the western parts of North-America, have been given by Moravian Missionaries.—See particularly the *History of the Missions of the United Brethren among the Indians in North-America.* By GEORGE HENRY LOSKIEL. Translated by LATROBE. 8vo. Lond. 1794.

JOHN LAWSON, whose work on *North-Carolina* is referred to in the above-mentioned page, was the Surveyor-General of that colony at the beginning of the eighteenth century. His work is a valuable one.

BRICKELL is also mentioned in connection with LAWSON, as having contributed to extend our knowledge of that country. But since that page was written, the author has ascertained that BRICKELL's work is nothing more than a villainous imposition. He put his name to LAWSON's work, and not only copied verbatim whole pages, but the entire volume, excepting merely those alterations which became indispensibly necessary to give some decent colouring to the imposture. BRICKELL's publication was made in 1737.

JEAN D'AUTEROCHE CHAPPE, a French astronomer, who was born in 1728, went, in 1769, to *California*, to observe

the *Transit of Venus*. His *Voyage to California* contains some interesting information concerning that country. He died there, some time after his arrival, of an epidemic disease.

M. Bossu was a Frenchman. His *Travels into North-America*, published at Paris, in 1777, are said to deserve but little credit.

Dr. John Mitchell, an Englishman, who resided some years in Virginia, and whose name has been frequently mentioned in this work, contributed not a little to extend our knowledge of American geography. His *Map of North-America*, published about the year 1755, was, for some time after its publication, the best extant.

Some valuable information respecting the geography of *Louisiana* was communicated to the public, in the course of the eighteenth century, by Crozat, Du Pratz, and Charlevoix. But our acquaintance with that part of North-America is extremely small and imperfect.

The geography of *Greenland* has been considerably improved by the Moravian Missionaries, who visited and resided for a number of years in that inhospitable region.—See a *Description of Greenland*, &c. by Hans Egede, who had been a missionary in the country for twenty years. Translated from the Danish. 8vo. London. 1745. See also the *History of Greenland*, &c. by David Crantz. Translated from the German. 2 vols. 8vo. 1767.

D'Anville. p. 352.

Jean Baptiste Bourguignon D'Anville, Geographer to the King of France, was born in 1697. He was one of the most diligent and enthusiastic geographers that ever lived. He is said to have laboured *fifteen hours a day*, for *fifty years*, to improve this favourite science. He died in January, 1782. The extent and value of his labours, for the illustration both of modern and ancient geography, are generally known.

Ancient Geography. p. 352.

Our knowledge of *Ancient Geography* has been considerably improved by the labours of Mr. Jacob Bryant.—See particularly his *Observations on Ancient History*, &c.

Map-Makers. p. 353.

Several of the persons mentioned in this page are erroneously represented as *constructors* of Maps and Charts. They were only distinguished *venders* of these articles.

Among the constructors of *Maps*, the additional names of DE BOUGE, LOPEZ, BOWLES, MOLL, PALAIRET, LA ROUGE, SENEX, and JEFFREYS, are worthy of respectful notice.

Maps of the United States. p. 352.

No *general* map of the United States, that can be called *correct*, has yet been published. That of ARROWSMITH is the best, and is highly respectable. But good maps of most of the individual States have been presented to the public. Of these the following is an imperfect list:—*New-Hampshire*, by HOLLAND; *Vermont*, by WHITELAW; *Rhode-Island*, by HARRIS; *Connecticut*, by BLODGET; *New-York*, by DE WITT; *Pennsylvania*, by SCULL, and by HOWELL; *Maryland* and *Delaware*, by GRIFFITHS; *Virginia*, by FRY and JEFFERSON; the country west of the *Alleghany Mountains*, by HUTCHINS, IMLAY, LEWIS, and WILLIAMSON; *North and South Carolina*, by MOUZON, PURCELL, and others; and *Kentucky*, by BARKER.

DE WITT'S *Map of the State of New-York.* p. 354.

The map, which is stated in the above-mentioned page to be in great forwardness, has been since published, by SIMEON DE WITT, Esq. Surveyor-General of the State of New-York. This map is probably the best delineation that has yet been given of any part of our country.

NOTE ON CHAPTER VI.

Standard of Measure. p. 365.

THE inaccuracy to which a standard of measure, derived from the common pendulum, is liable, arises from the difficulty of measuring the precise distance between the real point of suspension, and the centre of oscillation of the pendulum.

To obviate this difficulty, Mr. HATTON, and after him, still more successfully, Mr. WHITEHURST, devised their improvements. Since the publication of Mr. WHITEHURST, Sir GEORGE SHUCKBURGH EVELYN, assuming his principles, and pursuing his path, has made further experiments, which throw new light on the subject.—See *Philos. Trans.* 1798. p. 174.

The method adopted by the French Institute for obtaining an invariable standard of measure, is to assume a certain portion of the whole circumference of the earth. For this purpose they actually measured on a great circle of the earth, the distance between *Dunkirk* and *Barcelona*. The portion of the meridian from *Dunkirk* to *Rhodes* was measured by DELAMBRE, and that from *Rhodes* to *Barcelona*, by MECHAIN. From this measurement the length of the whole meridian was easily calculated; after which a certain portion of the whole circle (a *forty-millionth*) was fixed upon as the standard of measure. This standard the French call the *Metre*, which is about equal to 39. 371 English inches.

NOTES ON CHAPTER VII.

Comparative Dimensions of Ancient and Modern Ships. p. 369.

WHEN it is asserted that the last age is remarkable for a great increase in the *dimensions* of ships, it is meant that this may be considered as a *general* truth. The vessels which, at

the beginning of the century, were sent on long voyages of discovery, or other important enterprizes, were, in many instances, as small as those which are now considered fit only for coasters.

"The trading vessels of the ancients were, in general, much inferior in size to those of the moderns. CICERO mentions a number of ships of burthen, none of which was below 2000 *amphoræ (quarum minor nulla erat duûm millium amphorûm)*, *i. e.* about 56 ton, which he seems to have thought a large ship. *(Cic. Fam.* xii. 15.) There were, however, some ships of enormous bulk. One built by PTOLEMY is said to have been 280 cubits, that is, 420 feet long, and another 300 feet: the tonnage of the former being 7182, and of the latter, 3197. *(Athenæus.)* The ship which brought from Egypt the great Obelisk that stood in the *Circus* of the Vatican in the time of CALIGULA, besides the Obelisk itself, had 120,000 *modii* of *lentes*, or *lentiles*, a kind of pulse for ballast, amounting to about 1138 tons. *Plin.* xvi. 40. § 76."—See ADAMS's *Antiquities.*

BRINDLEY. p. 374.

JAMES BRINDLEY, the celebrated engineer, was born in Derbyshire, in the year 1716. He early devoted himself to mechanical pursuits; and was bred a mill-wright. His astonishing enterprize, and useful improvements in the formation of *aqueducts, canals*, &c. are generally known, and will long do honour to his memory. He died in 1772, in the 56th year of his age.

NOTES ON CHAPTER VIII.

Cultivation of the Potatoe. p. 382.

IT is a curious fact, that this most excellent vegetable has been in common use in *North-Britain* but a few years. In *France* it has been long known; but was, for many years, expressly proscribed, in consequence of its belonging to the

genus *Solanum*, a very suspicious family of plants. The revolution in that country, however, has brought it into use, and the prejudices against it are gradually yielding to experience.

In many parts of Germany, prejudices still more inveterate against the use of the Potatoe prevailed. We are told, indeed, that in some parts of that country, until within a few years past, the inhabitants would almost consent to starve rather than eat this pleasant and most useful vegetable. Count RUMFORD exerted himself to bring it into favour in *Bavaria*, and at length succeeded. At the close of the 18th century it had come into general use in most of the countries of Europe.

Rice and Cotton in South-Carolina. p. 384.

The cultivation of *Rice* in South-Carolina has undergone several revolutions in the course of the last thirteen years. In the year 1790, 87,179 tierces of this article were exported from that State. In 1792, 102,235 tierces were exported. Since that time the quantity exported has been, with some variations, generally diminishing. In 1800 the number of tierces amounted only to 64,769.

The progress of the cultivation of *Cotton* has been much more remarkable. In 1790, the quantity of cotton exported from South-Carolina was 9840 pounds; in 1795, 1,109,653 pounds; in 1800, 6,425,863 pounds; and in 1801, 8,301,907 pounds.

For the above information the author is indebted to the politeness of Dr. JOHN PARKER GOUGH, of Charleston.

Artificial Meadows.

The formation of *artificial meadows* is, it is believed, in a great measure, if not entirely, a peculiarity of the eighteenth century.

Gardening. p. 385.

Cultivated *Fruit Gardens* may also be considered as chiefly belonging to the eighteenth century. At any rate, the improvements in this department of agriculture, during the cen-

tury, were great and important. Since the time of the celebrated PHILIP MILLER, who was styled, by foreigners as well as his countrymen, *Hortulanorum Princeps*, many writers on this subject have contributed to the progress of improvement.

Rearing Cattle. p. 387.

Among those who have distinguished themselves by their successful attention to the breeding of cattle, particularly to the ascertaining those circumstances which affect the growth, size, strength, beauty, &c. of cattle, Mr. BAKEWELL, of Great-Britain, has particularly distinguished himself. The munificent encouragement given to improvements of this kind by the late Duke of BEDFORD and Lord SOMERVILLE, are also worthy of particular notice in sketching the agricultural progress of the last age.

NOTES ON CHAPTER IX.

Fire Engines. p. 395.

GREAT improvements have been made, during the age under consideration, in the construction of engines for *extinguishing fires*. The efficiency of those engines which have been formed for this purpose within the last twenty or thirty years, compared with those which were in use at the beginning of the century, is wonderfully great. The addition of an *air-cell* to these machines, by Mr. NEWSHAM, of London, greatly increased their power, and deserves to be mentioned as an important event in the course of their improvement.

Tanning. p. 399.

The mode of tanning leather with great expedition was first recommended by SEGUIN, of France. It was introduced into England by Mr. DESMOND, about the year 1795; and

has been frequently employed with great success. But it is said to be only eligible in cases of pressing necessity, where the process *must* be completed in a short time, being expensive, and, as some believe, in a degree injurious to the leather. The liquid for tanning leather, according to this method, is obtained by digesting *oak bark*, or other proper material, in water, frequently drawing off the water, and pouring it upon fresh tan, until the liquor is highly coloured, and very strong. Into this liquor the hides are immersed for a few days, after being previously prepared for tanning by means of *gallic lixivium* and *vitriolic acid*.

NOTES ON CHAPTER X.

Collections of Specimens in the Fine Arts. p. 305.

IN the opinion expressed in this page, that " the monuments of human genius, especially in Painting and Sculpture, collected and displayed in the city of Paris, were more numerous and magnificent than were ever before displayed in one place," there is evidently a mistake; at least the statement is by no means true, as it respects Sculpture. We have but very few of the fine works of antiquity. ADRIAN's *Villa* possessed more than all Europe at present.

Portrait Painters. p. 411.

ROMNEY is entitled to a place among the distinguished *portrait painters* of Great-Britain.

ANGELICA KAUFFMAN, p. 411.

A friend, on reading what is said of this celebrated artist in the above-mentioned page, made the following remark:— " I think you speak in rather too strong terms of the genius of

ANGELICA KAUFFMAN. Although she is very high on the list of artists, her works have not sufficient force of character and composition to entitle her to such praise."

Landscape Painting. p. 411.

In *Landscape* painting MORELAND is entitled to respectful notice. He is said to have a very superior genius for this department of painting.

Painting on Glass. p. 413.

The finest specimens of JERVAS's talents in painting on glass are some copies from WEST, in the windows of St. George's Chapel, at Windsor.

Roman Sculpture. p. 415.

"Roman genius" in sculpture is improperly mentioned. A Roman school of this art is scarcely recognized.

ALGARDI. p. 415.

ALGARDI lived early in the eighteenth century. Among the numerous works on which his reputation is built, his famous specimen of *Alto Relief*, in St. Peter's, at Rome, deserves particular commendation. The subject is the appearance of St. PETER and St. PAUL to ATTILLA, when laying siege to Rome. It is one of the finest things to be seen in that city.

Impressions from Marble. p. 420.

The principal advantage attending the method of taking off an impression of any figures or writing drawn on *marble*, is the perfect *freedom* with which the figures or writing can be drawn.

RAPHAEL MORGHEN. p. 421.

The name of this celebrated engraver is erroneously spelled in the page above-mentioned. It is MORGHEN, not MORGAN. It is also a mistake to place him among the artists of Great-Britain. He is an Italian, and resides at Florence.

END OF THE FIRST VOLUME.